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# Transactions of American Society for Steel Treating

Vol. V June, 1924 No. 6

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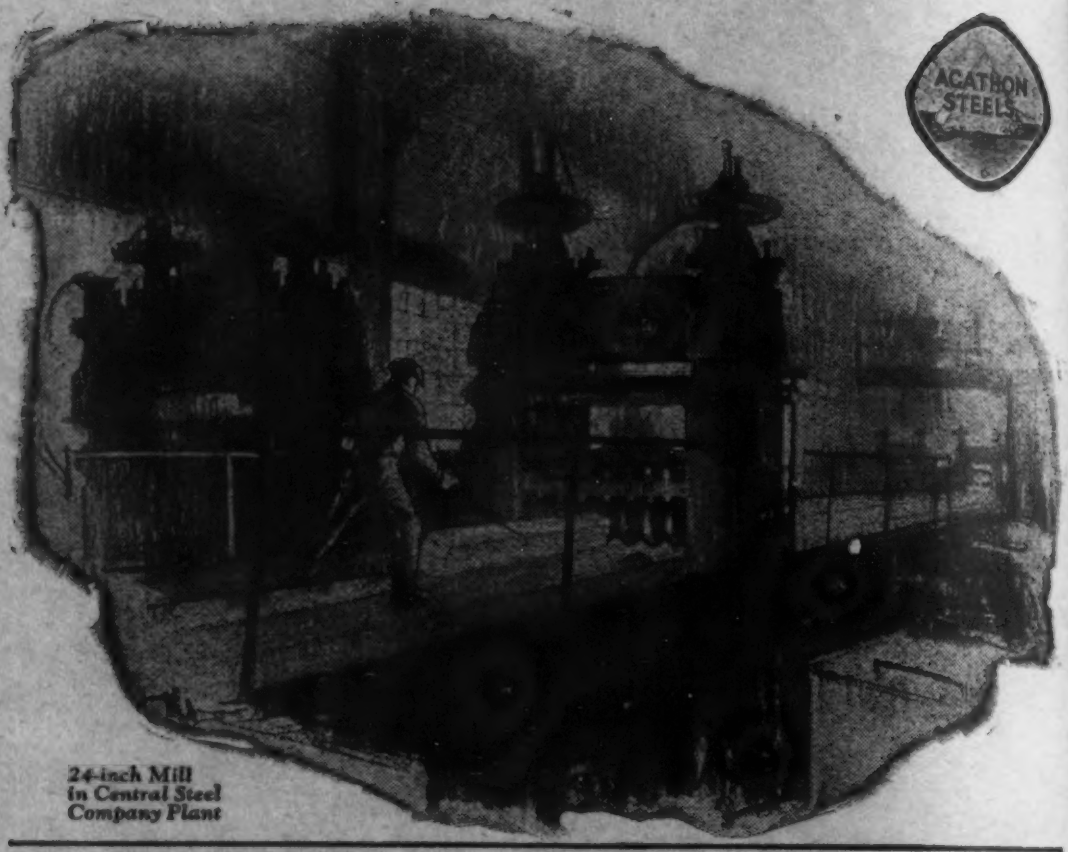


*24-inch Mill in Central Steel Company Plant*

# AGATHON ALLOY STEELS

OUR Metallurgical Department is maintained on the highest possible plane. It is abundantly supplied with the latest scientific equipment to be had and manned by a corps of expert metallurgical engineers and practical steel producers.

Through our years of experience in the production of commercial alloy steels this department has amassed and compiled a great amount of data on the adaptability of various special steels to hundreds of different lines of manufacture.

If a stronger, tougher or harder steel can be produced to meet the peculiar requirements of the highly stressed and excessive wearing parts of your product, our metallurgists can tell you and our mills can produce it. Write us. Get the co-operation of our organization and extensive facilities now. Remember it places you under no obligations.

We have daily production in all kinds of Agathon Alloy Steels such as—

Nickel, Chrome-Nickel, Uma, Molybdenum, Chrome-Molybdenum, Nickel-Molybdenum, Vanadium, Chrome-Vanadium, Chromium, etc.

Deliveries in Blooms, Billets, Slabs, Bars, Spring Flats, Hot Rolled Strips, etc.

## THE CENTRAL STEEL COMPANY, Massillon, Ohio

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*TRANSACTIONS*
*of the*
*American Society for Steel Treating*

Vol. V June, 1924 No. 6

## HISTORICAL NEW ENGLAND

MANY historical points of interest in the vicinity of Boston which will be visited by members and guests attending the convention of the American Society for Steel Treating, will be seen in the towns of Cambridge, Lexington and Concord. Many tablets

Washington Elm,
Cambridge

mark the spots where were enacted some of the most stirring events of the American Revolution.

### CAMBRIDGE

Passing through the beautiful Back Bay, over the Harvard bridge and through Cambridge, will be seen Harvard university, known the world over as one of the leading universities of

America. Memorial Hall, in Harvard college, is a notable example of the period when scarcely anything of beauty was built. Although this building itself is unbeautiful, the idea that caused it to be built was notably beautiful; for it was erected as a memorial to the men of Harvard who gave their lives for their

Memorial Hall,
Harvard College

country in the Civil war, and much of the interior is of striking effect. Down the lofty and impressive main corridor, there are tablets bearing such old New England names as Peabody, Wadsworth and Bowditch. The entire western end of the building is given over to a large dining hall, with capacity for over one thousand students. This room is paneled with oak, beautified by memorial stained-glass windows, as well as portraits and statues, all of which have an historic, and some an artistic interest.

Washington Elm is located just beyond Harvard square near the Common. There is affixed a tablet stating the historic fact that under this tree Washington first took command of the American Army (July 3, 1775). This tree was blown down in November, 1923.

Longfellow's home on Brattle Street, is one of the finest of colonial mansions. It was built about 1759 by Colonel John Vassall, a refugee of the Revolution. Washington took up his headquarters here when he first took the command of the American army, and here Madam Washington joined him. The estate afterward passed into the hands of various owners; was used as a lodging house

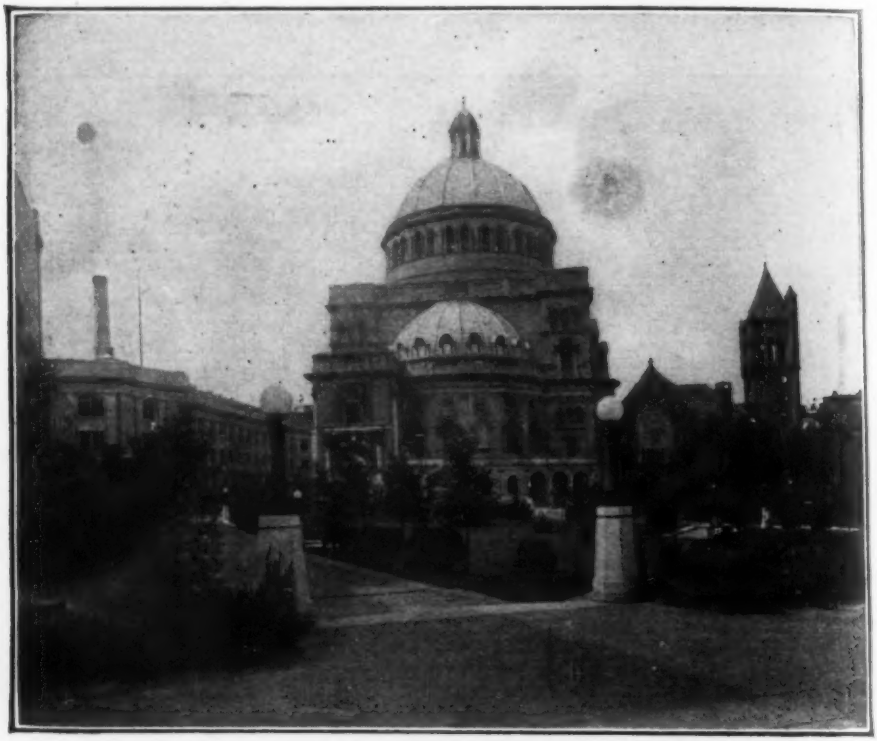
Home of Henry Wadsworth Longfellow, Cambridge

by Harvard professors; was occupied by such distinguished persons as Jared Sparks, Edward Everett and Joseph Emerson Worcester, the dictionary maker; and finally became the home of the poet Longfellow. It is now occupied by a daughter, Alice Longfellow.

The Christian Science Temple stands on Falmouth street, with beautiful grounds in front extending to Huntington avenue. It is 225 feet high, topped by a magnificent dome, and has a seating capacity of 5000. It has a melodious chime of bells, which are rung with pleasing frequency. This is the First Church of Christ, Scientist,—the "Mother Church" so called, generously endowed by Mary Baker Eddy, the founder of this denomination.

## Lexington

From Cambridge, passing through Arlington and arriving in Lexington, may be noted the battle field, where the farmers outside Boston first met the British with armed resistance, and where the historic words were first uttered by the commander of the Min-



Christian Science Church—Mother Church, Cambridge

ute Men on Lexington Green: "Stand your ground, don't fire unless fired upon, but if they mean to have a war let it begin here." Leaving the battle field, the Hancock-Clarke house, which contains priceless relics of the Revolution, may next be viewed.

## Concord

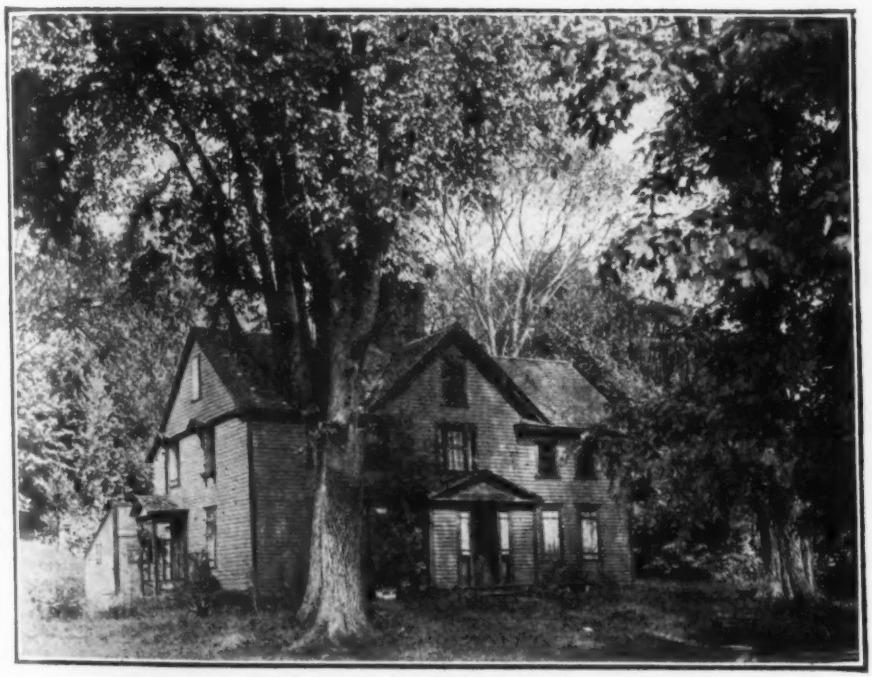
Leaving Lexington, the old town of Lincoln is passed through where is located the site of the capture of Paul Revere. Lincoln is also the home of Captain John Smith. Proceeding on to Concord, Merriam's Corner, the first point of interest in Concord, may be visited. Along the elm-shaded streets, may be seen the homes

of poets and writers who have made New England the mecca of all the world.

On Monument street, Concord, stands "Old Manse," where Ralph Waldo Emerson wrote "Nature" (1836). Nathaniel Haw-

Wayside,
Home of Nathaniel Hawthorne

Old Manse,
Concord



Orchard House,
Home of Louisa May Alcott.

thorne and his wife lived here during the first years of their married life.

The home of the later years of Nathaniel Hawthorne is known

as "Wayside" and was one of the earlier homes of the Alcotts. It was never among the finest of the old-time houses, but Hawthorne made alterations to please his own taste and developed the place into a quiet and attractive home. It is hemmed in by solemn evergreens, and from its place at the foot of the ridge, one may look across the sweeping meadows.

The home of Louisa May Alcott, where she wrote "Little Women" (1868), stands at the foot of a wooded ridge. Beside it is the little building once famous as the School of Philosophy.

## HOTEL ACCOMMODATIONS FOR THE BOSTON CONVENTION

IN ORDER that members and guests may be well taken care of in the matter of hotel accommodations during the time of the next annual convention in Boston, we are publishing a list of the hotels in the city of Boston. This list gives the number of rooms in each hotel and the rates.

It is essential and advisable that hotel reservations be made immediately, and members are requested to send their reservations directly to the manager of the hotel at which he wishes to be located, stating time of arrival, kind of accommodations desired, and the price he desires to pay. It is further advisable that the hotel management be requested to acknowledge receipt of your reservation.

Following the list of hotels is a tabulation showing the distance of each of these hotels from the convention headquarters in Copley Square. Likewise the distance from each of these hotels to Commonwealth Pier, where the exposition will be held, is tabulated in miles or fractions thereof.

**List of Boston Hotels***

*(Listed in order of nearness to Copley Square)*

**Copley Plaza**

| | |
|---|---|
| 1 person, with bath, inside | $ 5.00 to 6.00 |
| 1 person, with bath, outside | 8.00 to 10.00 |
| 2 persons, with bath, inside | 8.00 |
| 2 persons, with bath, outside | 11.00 to 15.00 |

**Westminster**

| | |
|---|---|
| 1 person, with bath | 3.50 |
| 2 persons, with bath | 6.00 to 7.00 |
| 4 persons, with bath, suites | 12.00 |

*All European plan except otherwise stated.

**Brunswick**

| | |
|---|---|
| 1 person, without bath, with running water | 2.50 to 3.50 |
| 1 person, with bath | 4.00 to 5.00 |
| 2 persons, without bath, with running water | 5.00 |
| 2 persons, with bath | 6.00 to 8.00 |
| 4 persons, with bath, suites per person | 3.00 |

**Lenox**

| | |
|---|---|
| 1 person, without bath, with running water | 3.00 to 3.50 |
| 1 person, with bath | 4.00 to 6.00 |
| 2 persons, without bath, with running water | 4.00 to 5.00 |
| 2 persons, with bath | 5.00 to 8.00 |
| 4 persons, with bath, suites | 12.00 |

**Vendome**

EUROPEAN PLAN

| | |
|---|---|
| 1 person, with bath | 3.50 and up |
| 2 persons, with bath | 5.00 and up |
| 1 person, with bath, sitting room chamber | 5.00 and up |
| 2 persons, with bath, sitting room chamber | 7.00 and up |

AMERICAN PLAN

| | |
|---|---|
| 1 person, with bath | 7.00 and up |
| 2 persons, with bath | 13.00 and up |
| 1 person, with bath, sitting room chamber | 11.00 to 16.00 |
| 2 persons, with bath, sitting room chamber | 15.00 to 20.00 |

**Arlington**

| | |
|---|---|
| 1 person, with bath | 3.00 |
| 2 persons, with bath | 4.00 |

**Touraine**

| | |
|---|---|
| 1 person, with bath | 5.50 to 7.50 |
| 2 persons, with bath | 8.00 to 10.50 |

**Adams House**

| | |
|---|---|
| 1 person, without bath | 2.50 to 3.50 |
| 1 person, with bath | 4.50 to 6.00 |
| 2 persons, without bath | 4.00 to 5.50 |
| 2 persons, with bath | 6.50 to 10.00 |

**Somerset**

| | |
|---|---|
| 1 person, without bath | 4.00 |
| 1 person, with bath | 5.00 to 7.00 |
| 2 persons, without bath | 5.00 |
| 2 persons, with bath | 6.00 to 8.00 |
| 4 persons, with bath | 10.00 to 12.00 |

**Avery**

| | |
|---|---|
| 2 persons, with bath | 5.50 to 6.50 |

**Parker House**

| | |
|---|---|
| 1 person, without bath | 2.50 to 3.50 |
| 1 person, with bath | 3.50 to 6.00 |
| 2 persons, without bath | 4.00 to 5.50 |
| 2 persons, with bath | 5.50 to 8.50 |

**Bellevue**

| | |
|---|---|
| 2 persons, without bath | 5.00 to 6.00 |
| 2 persons, with bath | 8.00 to 12.00 |

**Young's Hotel**

| | |
|---|---|
| 1 person, without bath | 1.75 and up |
| 1 person, with bath | 3.50 and up |
| 2 persons, without bath | 4.00 and up |
| 2 persons, with bath | 6.00 and up |

**Essex**

| | |
|---|---|
| 1 person, without bath | 2.50 to 3.50 |
| 1 person, with bath | 3.50 to 5.00 |
| 2 persons, without bath | 4.00 to 5.00 |
| 2 persons, with bath | 6.50 to 8.00 |

**United States Hotel**

| | |
|---|---|
| 1 person, without bath, with running water | 2.00 to 2.50 |
| 2 persons, without bath, with running water | 4.00 to 4.50 |
| 1 person, with bath | 3.00 to 4.00 |
| 2 persons, with bath | 5.00 to 6.00 |
| 2 persons, with bath, suites | 6.50 |
| 3 persons, with bath, suites | 7.75 |
| 4 persons, with bath, suites | 9.00 |

**Commonwealth**

| | |
|---|---|
| 2 persons, without bath | 4.50 |
| 2 persons, with bath | 5.50 |

**Boston Tavern**

| | |
|---|---|
| 1 person, without bath | 2.00 to 2.50 |
| 2 persons, without bath | 3.50 |
| 2 persons, with bath | 5.00 |

**Healy's**

| | |
|---|---|
| 1 person, without bath | 3.00 |
| 1 person, with bath | 3.50 |
| 2 persons, without bath | 4.50 to 5.00 |
| 2 persons, with bath | 5.00 to 6.00 |

**American House**

| | |
|---|---|
| 1 person, without bath, with running water | 2.25 to 2.50 |
| 2 persons, without bath, with running water | 4.00 |
| 4 persons, without bath, with running water | 5.50 to 6.50 |
| 2 persons, with bath | 5.00 to 6.00 |
| 2 persons, with bath, suites | 8.00 |

**Quincy House**

| | |
|---|---|
| 1 person, without bath | 2.00 |
| 1 person, without bath, with running water | 2.50 |
| 1 person, with bath, with running water | 3.00 to 4.00 |
| 2 persons, without bath, with running water | 4.00 |
| 2 persons, with bath | 5.00 to 7.00 |

**List of Hotels Showing Their Location in Respect to Copley Square and Commonwealth Pier**

| Hotel | Number Rooms | Distance from Head-quarters. Miles | Distance from exposition. Miles | Address |
|---|---|---|---|---|
| Copley-Plaza | 500 | 0.0 | 2.25 | Copley Square |
| Westminster | 250 | 0.0 | 2.25 | Copley Square |
| Brunswick | 275 | 0.25 | 2.25 | Boylston & Clarendon Sts. |
| Lenox | 200 | 0.25 | 2.25 | Exeter St. |
| Vendome | 250 | 0.25 | 2.25 | Commonwealth Ave. |
| Arlington | 300 | 0.50 | 1.5 | Arlington Sq. & Chandler St. |
| Touraine | 225 | 0.75 | 1.75 | Tremont & Boylston Sts. |
| Adams House | 460 | 0.75 | 1.75 | 555 Washington St. |
| Somerset | 300 | 0.75 | 3.00 | Commonwealth Ave. |

| | | | | |
|---|---|---|---|---|
| Avery | 150 | 0.75 | 1.75 | Washington & Avery Sts. |
| Parker House | 321 | 1.00 | 1.25 | Tremont & School Sts. |
| Bellevue | 250 | 0.75 | 1.5 | Beacon Hill |
| Young's | 200 | 1.00 | 1.25 | Court & City Hall Sts. |
| Essex | 300 | 1.00 | 0.75 | Atlantic Ave. & Essex St. |
| United States | 250 | 1.00 | 1.00 | Essex St. |
| Commonwealth | 210 | 1.00 | 1.00 | Bowdoin St., Beacon Hill |
| Boston Tavern | 125 | 1.00 | 1.25 | 347 Washington St. |
| Healy's | 75 | 0.75 | 1.75 | 642 Washington St. |
| American House | 275 | 1.25 | 1.5 | 56 Hanover St. |
| Quincy House | 500 | 1.25 | 1.5 | Brattle St. |

## THE SPRING SECTIONAL MEETING

THE Spring Sectional Meeting of the American Society for Steel Treating held in Moline, Ill., Thursday and Friday, May 22 and 23, under the auspices of the Tri City chapter, proved to be one of the most interesting sectional meetings that has been held by the Society. Members from many of the chapters of the society gathered at the Hotel LeClaire, Moline, Ill., on the morning of Thursday, May 22. The registration of members took place between the hours of 9:30 and 10.30 a. m., following which, a technical session was held in the auditorium of the Moline club; Dr. George K. Burgess presiding at this meeting.

The first paper entitled, *"High Power Magnification in Metallography"* was presented by Robert G. Guthrie, metallurgist, Peoples Gas Light and Coke Co., Chicago; the second paper entitled, *"Macro Etching as Applied to Forging Practice"* was presented by J. H. Nelson, metallurgist, Wyman-Gordon Co., Worcester, Mass., and the third paper entitled, *"Steel under the Oxyacetylene Flame,"* was given by Prof. Alfred S. Kinsey, Stevens Institute of Technology, Hoboken, N. J. At the close of this session, an informal luncheon was served at the Hotel LeClaire.

At 2:00 p. m. the second technical session was called to order by Clyde Burgston. The papers presented at this session are as follows: *"Heat Treatment of High Speed Steel Dies,"* by C. B. Swander, metallurgist, Wagner Electric Corp., St. Louis, Mo.; *"Physical Properties and Methods of Annealing Intermediate Products of White Iron,"* by Anson Hayes and W. J. Diederichs, Iowa State College, Ames, Iowa, (presented by Dr. Hayes); and *"Grinding,"* by H. W. Dunbar, Norton Co., Worcester, Mass. This last

paper included a practical demonstration of the cutting capacities of various types of grinding wheels.

At 6:45 p. m. about 300 members and guests assembled in the dining room of the LeClaire hotel where an informal dinner was served. This dinner meeting was held in co-operation with the Tri City Technical Council, which is an organization comprising all of the technical societies in the Tri Cities. Following the dinner, James F. Lardner, Jr., presented the toastmaster, William Butterworth, president of Deere and Co., Moline, Ill., who entertainingly introduced the speakers of the evening. The first speaker, W. H. Stackhouse, general manager of French and Hecht, Davenport, Iowa, gave a very interesting address of welcome to the members and guests of the Tri City Technical Council and the American Society for Steel Treating. W. H. Eisenman, national secretary of the American Society for Steel Treating responded to Mr. Stackhouse's very cordial welcome, and expressed in his genial and entertaining way, the appreciation of the members of the American Society for Steel Treating for the kind hospitality and spirit of friendliness which had been so freely expressed by members and hosts of the Tri Cities. Following Mr. Eisenman's address, past-president T. D. Lynch presented president, Dr. George K. Burgess with a gavel. Toastmaster William Butterworth then presented Dr. Burgess, who gave a most interesting illustrated lecture depicting the work of the United States Bureau of Standards and its relationship to the industries of the country. Dr. Burgess explained in detail the manner in which the Bureau functions in aiding the many industries in solving their research problems. Stereopticon slides were exhibited, showing many departments of the Bureau which are devoted to the study of every phase of industrial development and research.

Throughout the evening the guests were entertained with vocal solos by Lilly Nott Cochrane and Robert A. Lynch.

### Friday, May 23—Plant Visitation and Golf Tournament

The committees of the Tri City chapter had arranged a most comprehensive and interesting plant visitation program which occupied the morning hours. Automobiles were assembled at the Hotel LeClaire and at 9 o'clock, were ready to depart for one

of the six groups of plants which were to be inspected. These groups are as follows:

Group I. John Deere Plow Company, Yellow Sleeve-Valve Engine Works, John Deere Harvester Works.

Group II. Velie Motors Corporation, Moline Tool Company, Borg and Beck.

Group III. Bettendorf Company, Zimmerman Steel Company.

Group IV. C. U. Scott and Son, Tri-City Heat Treating Company, Rock Island Plow Company.

Group V. Linograph Company, Davenport Locomotive Works, French and Hecht.

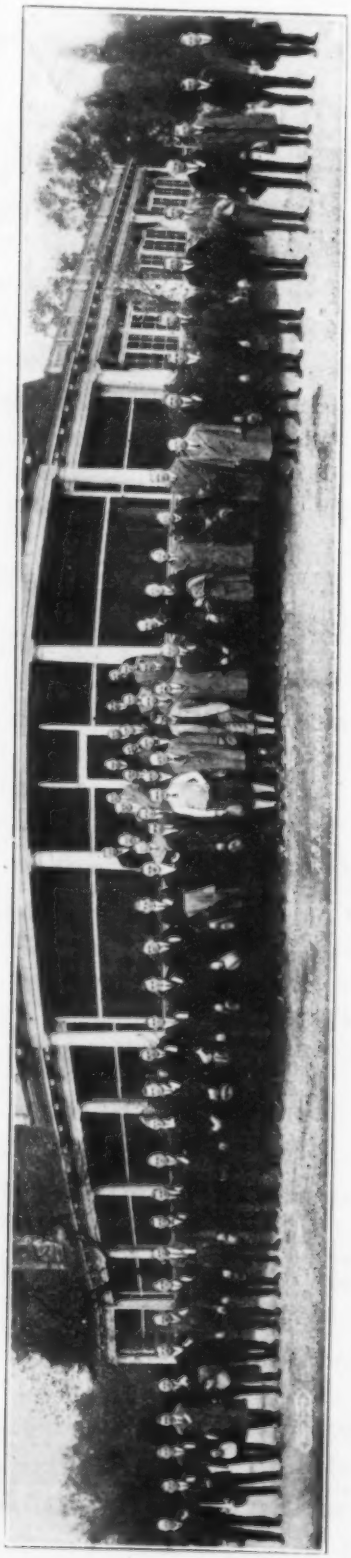
Group VI. Tri-City Malleable Castings Company, Union Malleable Iron Company, Moline Iron Works.

For those who desired to see plants other than those on the main list, arrangements were made whereby special guides conducted these members to the plants of the following companies:

Williams-White Company
Reynolds Engineering Company
Moline Plow Company
Marseilles Works
Moline Body Corporation
Bettendorf Oxygen Company
Davenport Machine and Foundry Company
Voss Brothers
O. E. Szekely Company
Red Jacket Pump Company
E. and T. Fairbanks Company

Simultaneous with the plant visitations, a golf tournament was scheduled at the Rock Island Arsenal Golf club. The committee in charge had arranged for two trophies, a first and second prize for the winners of the match. This was a blind bogey tournament thus giving all players an equal opportunity to win the trophy. The match consisted of one foursome and two threesomes as follows:

| | Score | Handicap | Net Score |
|---|---|---|---|
| R. T. Bayless | 116 | 45 | 71 |
| J. F. Harper | 121 | 27 | 94 |
| F. P. Gilligan | | (Played 6 holes only) | |
| Clyde Burgston | 118 | 35 | 83 |



Panoramic View of Members Who Visited the Rock Island Arsenal
Spring Sectional Meeting, Moline, Ill.

| | | | |
|---|---|---|---|
| Dick McDonnell | 140 | 45 | 95 |
| J. D. Hall | 131 | 45 | 86 |
| R. G. Guthrie | 101 | 15 | 86 |
| W. H. Hull | 116 | 20 | 96 |
| J. F. Lardner | 92 | 7 | 85 |
| L. A. Rowland | 126 | 25 | 101 |

Clyde Burgston, J. D. Hall, Robert G. Guthrie and James F. Lardner, Jr., were those who qualified in the match and upon drawing numbers, Robert G. Guthrie was awarded the first prize, a silver cup, and J. D. Hall was awarded the second prize of six golf balls.

At 1 o'clock, members and guests assembled at the Rock Island Arsenal Golf club where an informal luncheon was served, following which Colonel D. M. King, commanding officer of the arsenal gave a brief talk on the work that the arsenal is doing, and then personally conducted the party throughout the arsenal shops. This inspection trip concluded the scheduled program of this sectional meeting.

Much credit is due the Tri City chapter officers and members for their untiring efforts in arranging and conducting one of the most successful sectional meetings that the Society has held.

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## VOLUME V OF TRANSACTIONS COMPLETED

THIS issue of TRANSACTIONS completes Volume V, which covers the period from January, 1924, through June, 1924. Volume VI will include the period from July, 1924, through December, 1924. The index for Volume V is now ready and copies may be obtained upon request.

Those who desire to have their loose copies of Volume V bound in accordance with the style used in binding Volumes I, II, III and IV, may do so by forwarding them to the executive offices of the Society, 4600 Prospect avenue, Cleveland, together with $2.00, and they will be bound and returned to the owner promptly.

## UNAUDITED PROFIT AND LOSS STATEMENT
## AMERICAN SOCIETY FOR STEEL TREATING

### From January 1 to March 31, 1924

| | | | |
|---|---|---|---|
| **INCOME** | | | |
| Dues (gross) | | $10,668.50 | |
| Transactions Advertising | | 5,638.60 | |
| Transactions Sales | | 707.25 | |
| Bindery Account | | 339.50 | |
| Discounts Received | | 35.34 | |
| Interest | Dr. 61.92 | | |
| Data Sheets | | 558.00 | |
| Miscellaneous Receipts | | 199.69 | $18,084.96 |
| **EXPENSES** | | | |
| Discounts Allowed | | 38.28 | |
| Bindery Account | | 108.50 | |
| Reprints | | 77.38 | |
| Data Sheets | | 1,266.19 | |
| Library | | 30.00 | |
| H. M. Howe Medal Fund | | 4.43 | |
| Miscellaneous Expenses | | 61.14 | |
| Transactions | | 4,899.85 | |
| Secretary's Office | | 2,524.26 | |
| Treasurer's Office | | 439.42 | |
| Director's Expenses | | 526.85 | |
| National Committees | | 1,444.01 | |
| Rochester Sectional Meeting | | 383.36 | |
| Increase of Membership | | 18.86 | |
| Local Chapters | | 4,266.23 | 16,088.76 |
| Excess of Income over expense | | | $1,996.20 |

### BALANCE SHEET

| | | | |
|---|---|---|---|
| **ASSETS** | | | |
| Commercial Account Cleveland Trust Co | | $ 2,570.58 | |
| Savings Account Cleveland Trust Co | | 2,714.67 | |
| Savings Account Equity Savings & Loan Co | | 5,868.53 | |
| Savings Account Union Trust Co | | 1,082.42 | |
| Bond Investments | | 31,000.00 | |
| U. S. Treasury Certificates | | 2,015.00 | |
| Accounts Receivable for Advertising | | 1,986.19 | |
| Accounts Receivable Miscellaneous | | 1,121.24 | |
| Office Furniture & Fixtures | | 1,000.00 | |
| 1923 Convention Accounts Receivable | | 481.22 | |
| 1924 Convention Prepaid Expenses | | 3,083.08 | |
| Inventory January 1st, 1924 | | 2,119.48 | $55,042.41 |
| **LIABILITIES** | | | |
| Accounts Payable | | 1,494.43 | |
| Reserve for Dues Paid in Advance | | 10,000.00 | |
| Reserve for Doubtful Accounts | | 1,000.00 | |
| Permanent Convention Reserve | | 20,000.00 | |
| Advance Receipts 1924 Convention | | 4,903.75 | |
| H. M. Howe Medal Fund | | 3,000.00 | |
| Surplus, January 1st, 1924 | $12,672.03 | | |
| Cancelled 1923 Convention charges | 24.00 | | |
| | 12,648.03 | | |
| Profit from Jan. 1st to Mar. 31st, 1924 | 1,996.20 | 14,644.23 | $55,042.41 |

# THE GRANULATION HYPOTHESIS AND THE DELTA-GAMMA CHANGE IN IRON-CARBON AND IRON-NICKEL ALLOYS

By Colonel N. T. Belaiew

*Abstract*

*The author of this paper points out that the dendritic structure of alloys, as revealed by macro-etching, is a very stable structure and is not readily broken up during usual heat treatment operations. When the elements of secondary crystallization lodge themselves according to the symmetry of the dendrites, a structure arises called "the structure of large crystals." This structure when viewed by the unaided eye, shows a complete identity of picture with the dendritic structure. With the aid of the microscope, the outstanding feature of this structure is the discontinuity of the excess element, ferrite or cementite, which has segregated into pseudo dendrites or ferrite islets. This structure of large crystals occurs either in steels rich in carbon or in single crystals, and therefore is not of usual occurrence.*

*The usual structure of steel articles slowly cooled is that of a net-work. Under the microscope this structure is characterized by the continuity of the mesh and by the continuity of the outer shell of the excess element around the inner nucleus.*

*Based upon the investigations of the author and Giolitti, a discussion of castings and slowly cooled steels in relation to the structure of the dendrites, is included.*

*The author's granulation theory is described and discussed, and an explanation of the manner in which the delta-gamma transformation might account for the occurrence of granulation in alloys, cooled down from the melt, is given.*

## Introduction

THE observations and experiments of Tschernoff, Howe, Sauveur and their followers have demonstrated that iron and steel solidify in dendrites, usually of *macroscopic* size.

On the other hand, either steel castings or any other

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A paper to be presented before the Sixth Annual Convention of the Society to be held in Boston, Mass., Sept. 22 to 26, 1924. The author, Colonel N. T. Belaiew, is consulting metallurgist, 33 Elvaston Place, Queen's Gate, London, England. Written discussion is invited.

steel article, not specially treated, would show on a plane section a more or less distinct network *microstructure,* pointing to the existence of a certain number of crystalline grains of a shape and size very different from that of the dendrites.

These were the main facts which attracted the author's attention in the early years of this century, when under the guidance of his teacher, Prof. D. K. Tschernoff, he was about to start experimental researches on the crystallization of steel. From the start the author was animated by the desire of bringing into closer harmony the processes of crystallization with various areas of the carbon equilibrium diagram. Two main processes were to be considered: First, the process of primary dendritic crystallization, so brilliantly demonstrated by Tschernoff, in steel castings and in damascene steels; second, the formation of various grains of alpha and gamma iron, as conceived by Osmond and linked up in his early works with the existence of simple and complex cells.

Dendritic crystallization, being a solidification process, linked itself up quite naturally with the upper part of the diagram, between the liquidus and solidus branches, (Fig. 1). The formation of alpha-grain and the final secondary structures also found quite easily their appropriate positions in the transformation zone GOSL (Fig. 1). There remained, however, the gamma-grain, whose genesis and occurrence seemed to the author to necessitate a more detailed study.

The prospect of studying the alpha and gamma-grains on the same sample, and if possible on the same section, seemed eminently attractive, and the author's early efforts were directed towards the realization of large, well-developed structures, visible to the naked eye.

For this purpose, when preparing samples at the Poutiloff works in 1907, the crucible method was adopted and the alloys were allowed to cool down together with the furnace as slowly as possible, thus realizing the conditions specified for damascene steel by Anossoff and Tschernoff[1]. About 20 alloys with carbon content varying between 0.40 and 2.30 per cent were thus prepared under conditions of very slow and

1. The numbers refer to the bibliography which appears at the conclusion of this paper.

undisturbed cooling; the interval between 1500 and 290 degrees Cent. (2732-554 degrees Fahr.) usually being about 60 hours.

Under these conditions all of the alloys developed a very

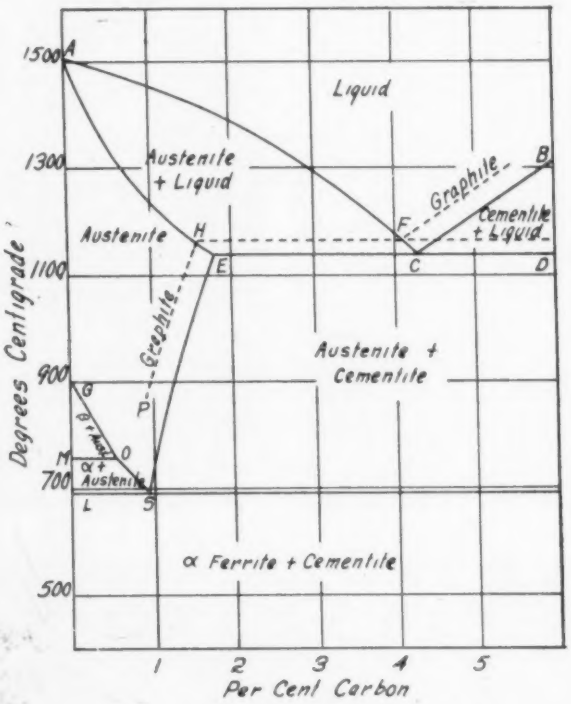


Fig. 1—Equilibrium diagram of iron-carbon alloys. (After Carpenter).

fine primary as well as secondary, crystallization[2]. Particularly beautiful were the outer crusts of the alloys No. 1 (carbon 1.80 per cent) and Nos. 5 and 6 (carbon 0.60 per cent) and their corresponding macro-etchings on the inner sides of the crusts. These are reproduced on Fig. 2 and Fig. 3.

The general outline of the markings on the Fig. 2 resembles very closely the picture of the primary dendritic crystallization on the outer crust. The secondary deposits, in this case cementite and pearlite, closely follow up the dendritic axes and branches. Here the secondary crystallization has not only been influenced, but predetermined by the primary one.

Quite a different aspect is presented by the alloy No. 5 with

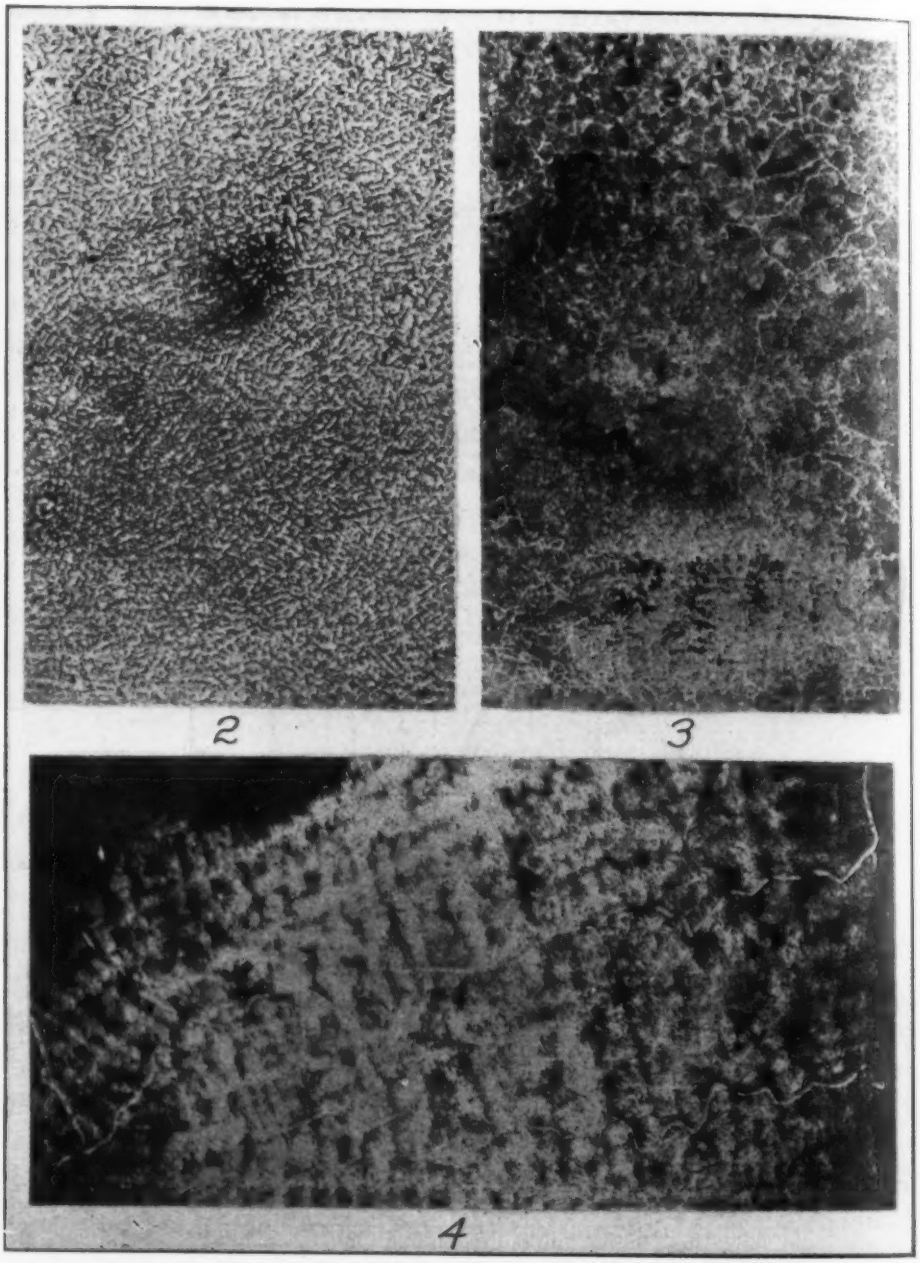


Fig. 2—Structure of large crystals. Alloy No. 1, carbon 1.80 per cent. Pearlite and cementite. x 1. Fig. 3—"Network structure." Alloy No. 5, carbon 0.60 per cent. Pearlite and ferrite. x 1. Fig. 4—Primary crystallization (dendritic structure) and secondary crystallization, ferrite mesh simultaneously revealed by macroscopic etching. Alloy No. 6, carbon 0.60 per cent. x 6.

0.60 per cent carbon (Fig. 3). Here, apparently, no trace of dendritic influence was left. In spite of the large size of the meshes, the general character of the network is distinctly

polyhedral, closely resembling, only on a much larger scale, the usual structure of rails and similarly treated articles.

Clearly, some fundamental change must have occurred in the specimen previous to the deposition of the meshes of the net. This change, on the other hand, must have been posterior to the formation of the dendrites, as by combined macro- and micro-etching, the structure of both the dendrites and the mesh is revealed simultaneously (Fig. 4). Thus we have to look for this change somewhere in the region between the areas of primary and secondary crystallization, that is, in the austenitic zone.

## Secondary Structures in Steel on Slow Cooling

Let us examine more closely the structure of the alloy No. 1, with 1.80 per cent carbon. The most striking feature of that structure is its close resemblance, or identity with the dendritic structure; there are in both, the same axes and branches and the same rectilinear intersections. An examination of that alloy at higher magnifications reveals another characteristic—the *discontinuity* of the excess element, in that case cementite (Fig. 5). The cementite needles, shown in that photomicrograph, have agglomerated in the interstices of the primary dendrites and have arranged themselves in groupings of roughly dendritic appearance[3].

Such structure is not, however, limited to the higher carbon steels. Under certain circumstances it appears in hypoeutectoid steels as well. So in Fig. 6 is reproduced a portion of the alloy No. 5 with 0.60 per cent carbon. The spot selected is in the region of the pipe and consequently is rather rich in slag inclusions. The excess element, ferrite, has crystallized out in well defined particles, around a string of slag. The general outline of the masses is somewhat reminiscent of the rounded branches of the dendrites, and like cementite in the alloy No. 1, the ferrite particles in that particular section of the specimen, are arranged in a *discontinuous* grouping.

The structure of the Tschernoff crystal (carbon content 0.60 per cent carbon) is, in its general outline, very much like that of the alloy No. 1 (Fig. 7). At a higher magnification the ferrite masses are seen to have segregated into discontinuous

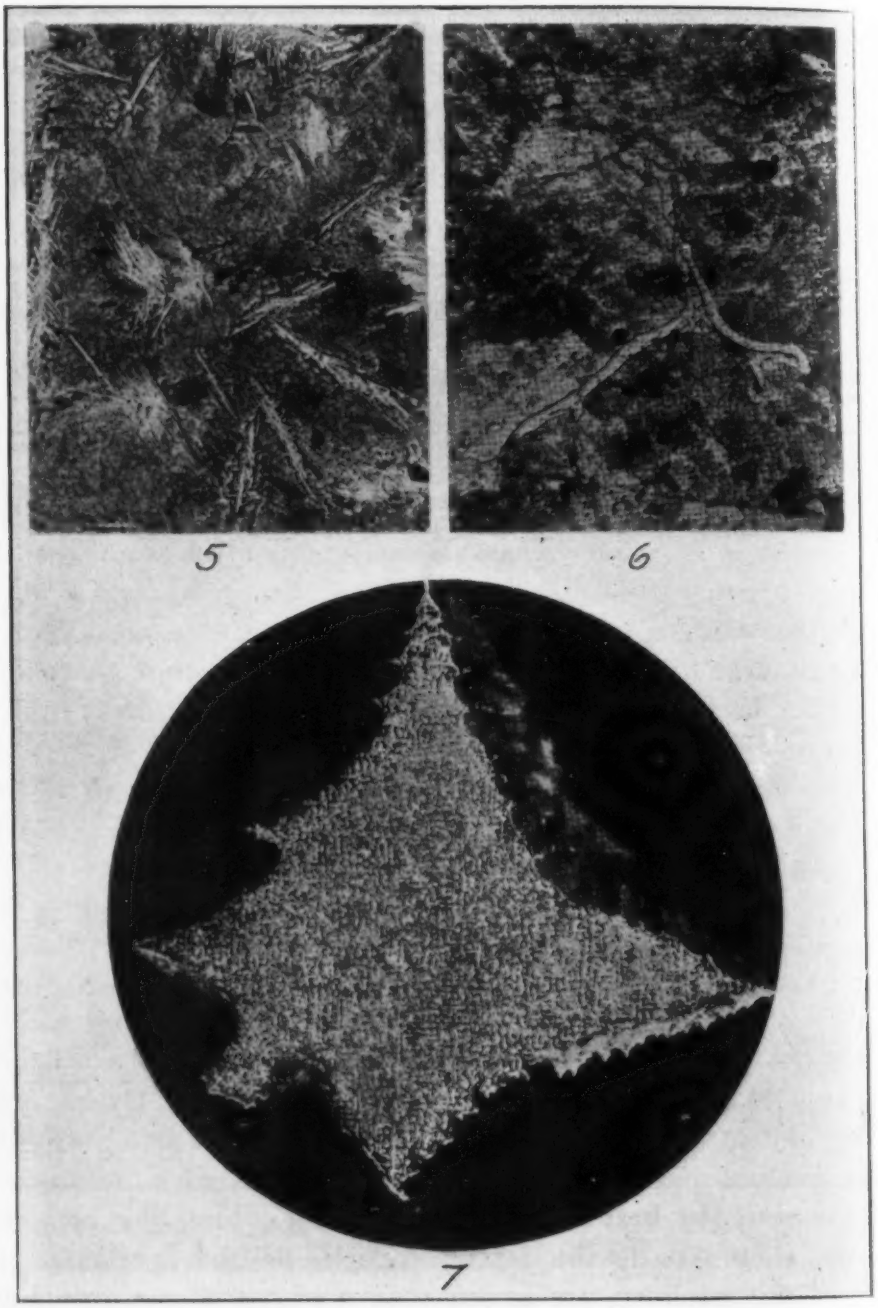


Fig. 5—Showing discontinuity of the excess element in the structure of large crystals. Alloy No. 1, carbon 1.80 per cent. Cementite and pearlite. x 50. Fig. 6—"Structure of large crystals" showing ferrite islet. Fig. 7—"Structure of large crystals." Tschernoff's crystal. Carbon 0.60 per cent. Ferrite and pearlite. x 1½.

groupings; in detail very much like that of Fig. 6 (Fig. 8).

Thus, such a structure occurs in a very wide range of chemical composition, and closely resembles that of the primary dendrites, as it brings into evidence by means of *secondary* deposits, the axes and branches of the *primary* dendritic crystals. In this triad of secondary structures[5], the author has suggested the term, *structure of large crystals.*

The structures of large crystals show the character and mode of distribution of the secondary deposits, if and when, they follow up the dendritic axes and branches. As already mentioned, the general character of this structure at low magnifications will have a distinctly dendritic appearance. At higher magnifications the excess element will appear in isolated, discontinuous masses.

If the secondary crystallization were influenced always and only by the chemical and crystallographical character of the dendrites, the general picture of the secondary structures would always be that of the structure of large crystals. This, however, is not the case, and the structure of large crystals, far from being the general rule, has to be looked upon rather as an exception. On the other hand, every day shop practice and the usual laboratory experience show that the structure of steel articles of usual chemical composition not specially treated is generally that of the network structure. The common appearance of such alloys is very much like that of the alloy No. 5 (Fig. 3), only that the structure of the former is on a much smaller scale.

Let us examine more closely Fig. 3 and Fig. 9. As in the usual steel specimen the size of the meshes decrease from the central parts towards the periphery, thus suggesting the influence of the velocity of cooling and of the maximum temperature; the characteristic "continuity" of the ferrite mesh is also to be noted. If Fig. 3 were compared with the outer part of the crust of the same alloy[6], or if the same section as in Fig. 3 were examined under oblique illumination, it would become evident that the larger meshes comprise several dendritic systems, whereas the smaller mesh cuts one system into several parts.

In order to reveal simultaneously the two structures, on

one and the same sample, i.e. the structure of the primary dendrites and the secondary net, the author applied a combined macro- and micro etching and was finally able to obtain the picture shown in Fig. 4. This picture shows the manner in which the white string of ferrite cuts through several dendritic branches, thus assigning to one inner crystallographic system, portions of different dendrites, or, as in other parts of the figure, comprises within one envelope several different dendritic systems with various orientation of their axes and branches.

As in Fig. 4 both pictures exist simultaneously, it is evident that the dendrites have not been completely obliterated during the subsequent cooling through the austenitic and the transformation zones. On the other hand, the dendrites still must have lost something of their individuality, as the insidious mesh was allowed to cut through their bodies.

In his previous writings the author has always insisted on the importance and brought forward the idea, that a dendrite is not only a *chemical,* but a *crystallographical* entity as well[7].

The chemical nonhomogeneity of the dendrites, resulting sometimes in coring, but usually in the small pits brought into evidence by macro-etching, remains substantially unchanged from the solidus line down to atmospheric temperature. This is the reason that a suitable macro-etching reveals on the same specimen, the same dendritic structure, no matter what the intermediate treatments were.

A very comprehensive study of the subject, based on the shop practice of the Poutiloff steel works in Russia, was published in 1910 and 1912 by the author's friend and colleague, the late N. I. Belaiew, then metallurgical engineer at the works and in charge of all the heat-treatment operations[8].

N. I. Belaiew collaborated with the author in his first experimental researches on the crystallization of steel, conducted in the spring of 1907 at the steel foundry of the Poutiloff works, and the author desires to put on record his indebtedness to the invaluable assistance rendered by his late friend.

He would also like to take this opportunity to direct attention to the great importance of N. I. Belaiew's researches,

which proved without a shadow of doubt, that the dendritic systems of primary crystallization are extraordinarily stable, as is, indeed, the nonhomogeneity of the solid solution. Further, he demonstrated that the usual shop practice heat treatments, like annealing, tempering and quenching do not suppress or even modify the dendritic structure, so that after a complete cycle of such treatments the final macro-etching reveals again the same original structure[9].

The same results were arrived at quite independently by F. Giolitti, and interesting data on the subject was published in his book on heat treatment of mild steel, and more especially, in his paper on the "Relationship between Dendritic Structure and the Ferrite Mesh," contributed in 1920[10].

A comparison of the results published by the author in his thesis and in other early papers with those obtained by N. I. Belaiew, and finally, with those of Giolitti, shows first, that the chemical nonhomogeneity of the dendrites remains unaltered under the usual heat-treatments used in shop and laboratory practice; secondly, it shows that one and the same dendritic system can be associated with an unlimited number of different networks with meshes largely varying in size and in character. It follows that there is no relation between the dendritic structure and the ferrite mesh[11].

It is a matter of great satisfaction to the author to find himself in close agreement on that important, but rather controversial point, with the eminent Italian metallurgist. It seems to him, however, that a further step must be taken and the implicit inference drawn, that, while the chemical composition of the dendrites remains unaltered, their crystallographic "integrity" is destroyed and, therefore, the ferrite mesh depends on a new crystallographic unit—the gamma-grain, or, as the author calls it, the *granula*.

On that point there does not seem to be any real divergence of opinion between the views of the author and of Giolitti. The only difference is that Giolitti is less explicit on the matter. So he says: "Unquestionably these two systems of crystals, dendrite and mesh, are morphologically independent during simple reheating to 900 degrees Cent. (1652 degrees Fahr.). Therefore, if ferrite mesh is dependent upon

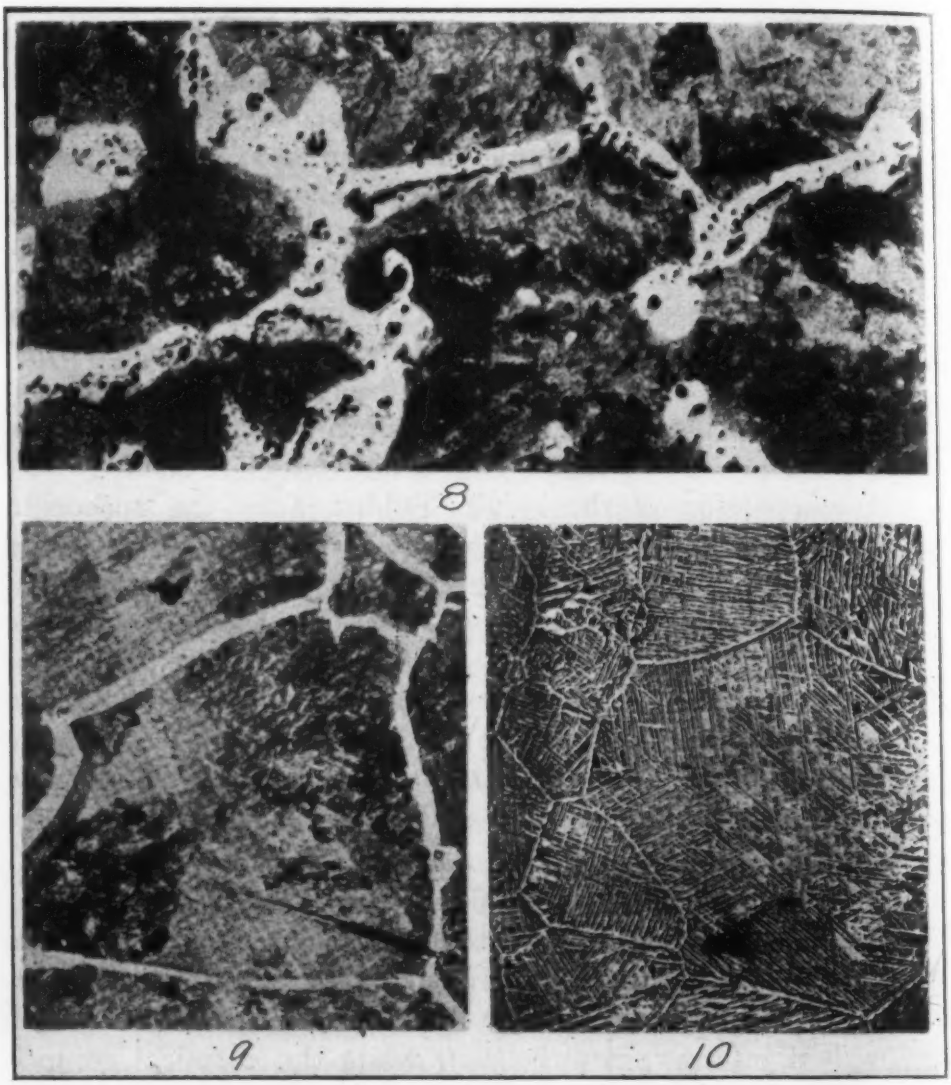


Fig. 8—Tschernoff's crystal. Carbon 0.60 per cent. This shows the discontinuity of the excess element in the structure of large crystals. Ferrite and pearlite. Fig. 9—"Network structure" showing the continuity of the excess element in the network structure. Alloy No. 5, carbon 0.60 per cent. Ferrite and pearlite. x 40. Fig. 10—"Widmanstatten structure." Widmanstatten figures reveal octohedral cleavages of the gamma-grain. Alloy No. 8, carbon 0.55 per cent. x 4.

a system of primary crystals, the primary crystals, in turn, must be independent of the dendrites developed by deep etching"[12], and further: "So called granulas or coarse crystals in the fracture are certainly not essentially due to the development of the *fir-tree* crystals, but rather, are connected very closely with the state of the ferrite meshwork,"[13]

In the author's opinion, the "primary crystals" referred to in the first instance and the "so-called granulas or coarse crystals" in the second, are the *gamma grains* or *granulae;* he, further, as in his previous writings, suggests the name of *granulation* for the process in the austenitic region, which by destroying the crystallographic unity of the dendrite, brings these new units into being.

## The Gamma-Grain or Granula

Let us study now the morphology of the gamma-grain. A crystalline grain is an allotriomorphic crystal, i.e. a body built up of crystalline matter, but not possessing the form of a regular polyhedron. The internal crystalline matter is symmetrically arranged in space in accordance with one or the other space lattice, and is uniformly orientated in every grain; that orientation, however, changes from one grain to the other.

The first task, therefore, in establishing the nature of the gamma-grain is to bring into evidence the crystalline arrangement of the matter inside the grain.

The most suitable method for that purpose proved to be the method of secondary structures. Many years ago Osmond expressed himself on the subject as follows:

"When a liquid or a solid deposits successively, several solid phases, the secondary and tertiary masses often preferably lodge between certain of the crystallographic planes of the primary deposit and thus illustrates its structure."[14]

Thus it is to be expected that under suitable conditions the inner crystallography of the grain may be made apparent. As shown by the author, such conditions are present when the Widmanstatten structure occurs[15]. Fig. 10 shows how the excess ferrite has been arranged inside every grain in Widmanstatten figures, representing the octahedral sections[16]. Thus the cleavage planes of the gamma-grain are octahedral planes. On the other hand, for substances crystallizing in the regular system, the occurrence of octahedral cleavage is a sure indication of the face-centred cubic lattice.

To sum up, we may say that the matter inside every ferrite shell is arranged in a regular manner, according to the face-centered lattice of the regular system and is, therefore, a crystalline body.

Consequently, the volume inside every shell is a crystalline grain or granula[17]. The next question which naturally arises is, when and where does the formation of the gamma-grain take place?

As previously stated, it cannot take place in the transformation range, as the occurrence of the Widmanstatten figures point to a previously existing orientation. What the author actually means is this: When the alpha-ferrite is forced to crystallize out on the spot, it has no other option other than to lodge itself in the cleavage planes of the matrix; this is what it does. The cleavage planes clearly belong to the symmetry of the already existing matrix and not to that of the new deposits. Therefore, the cleavage planes, and generally speaking, the octahedral symmetry must have been in existence before the new deposits came into being, i. e. before the transformation range.

If the existence of the gamma-grain can thus be traced to the austenitic region, it is important to determine whether that can be done throughout the whole of it, up to the solidus line, or, whether, the formation of the gamma-grain occurs in regions immediately preceding the transformation range.

A direct answer to this query is furnished by the experiments of Professor A. Baykoff, of the Polytechnic Institute in Petrograd[18]. Independently from Osmond, he used the same methods of etching specimens at high temperature with hydrochloric acid, in the absence of air. Baykoff followed up this line of research, studying the structure of metals "in situ," so brilliantly inaugurated by Saniter[19]. By a series of experiments on steels of chemical composition varying from that of 0.12 to 1.94 per cent carbon and extending through the whole range of temperatures from 870 up to 1120 degrees Cent. (1598 to 2048 degrees Fahr.) he had been able to prove the existence of polyhedral structure, and consequently, of the gamma-grain throughout the austenitic zone up to as high a temperature as 1120 degrees Cent. (2048 degrees Fahr.).

The etching thus obtained, remains unaltered through cooling down to the room temperature and can be examined under the microscope. The various photomicrographs bear a striking resemblance to the structures obtained by Maurer, and likewise, to the polyhedral structure of the austenitic alloys.

It follows that at temperatures as high as 1120 degrees Cent.

(2048 degrees Fahr.) the gamma-grain did already exist, and consequently, the granulation process had also taken place. That brings us up to the upper part of the austenitic zone, rather close to the solidus line. It is to these regions that we have to look for the traces of the gamma-grain in specimens cooled down slowly from the melt.

As intimated by the author in his early writings[20], the granulation process, being a recrystallization process, will be governed by the laws of Tammann, for the spontaneous velocity of the origination of nuclei and the linear velocity of crystallization. In steel, as in other metals, the first is rather low at higher temperatures (under the solidus line) and increases up to a certain limit, with the fall of the temperature; the linear velocity, on the other hand, attains greater values at higher temperatures. Therefore, when the process of granulation starts at a very high temperature, the number of nuclei will be relatively small and the grains few and large. That will be the case of alloys cooled down from the melt, for instance, the alloy No. 5 and generally, that of the castings.

On the other hand, if a specimen is raised to a temperature just above the transformation range, the number of nuclei will be very large and the size of grains very small. That is the reason that in rails and like articles, the granulation leads to a network on a comparatively small scale, and the same granulation in the alloys prepared by the author, or in those examined by Giolitti—gives rise to granulae several millimeters wide, so that the whole meshwork is perfectly visible to the unaided eye.

Regardless of the size of the granulae, even though macroscopic they have no relation to the dendritic structure. It follows, that regardless of the temperature of the upper limit of the granulation zone, the process is different from that of primary crystallization. Consequently, some modification of the usual equilibrium diagram seems necessary to fit in the observed facts of the granulation process[21].

These and similar considerations influenced the author, when delivering a lecture to the Institute of Aeronautical Engineers (1920) on the structure of steel, to suggest that the process of granulation might be linked up and even caused by the allotropic change in iron, i. e. by the appearance of a new phase[22].

## Granulation and Delta-Iron

An allotropic change in iron in the upper austenitic range was suspected as long ago as the nineties of the last century. E. J. Ball in a paper "On the Changes in Iron Produced by Thermal Treatment," read before the Iron and Steel Institute in 1890, drew attention to a third "new" point on the thermal curves at about 1300 degrees Cent. (2372 degrees Fahr.)[23] and added the following remarks: "What the change is which occurs at the critical point must be the subject of further examination, but the point itself is most distinct, and the change in the nature of the metal, which reaches its maximum at this temperature, must be very considerable, as indeed, the above experiment shows."[24]

A most significant observation was further made in the discussions on that paper by A. Wingham, who said, that it appears from Dr. Ball's paper, "that the iron at very high temperatures, but below melting, changed, again into a form having properties, which might be similar to those of the original modification."[25]

How suggestive these remarks seem to us now, in the light of recent X-ray examination of the atomic structure of alpha-gamma-delta-iron, but then, apparently, they could not be appreciated, and for a considerable period, the interest to the upper austenitic region was dying down.

Mention must be made, however, of the efforts of Professor A. L. Baboshin, of the Petrograd Mining Institute, to revive that interest and to link up the processes in this region with Tschernoff's point "b". A series of most suggestive articles were published by Baboshin on the subject, in the proceedings of the Russian Metallurgical society and, lately, in his comprehensive treatise on the metallography and heat-treatment of iron and steel[26].

Various reasons, however, deflected the attention of the metallurgical world from the path opened by these researches, and it fell to the lot of Messrs. Ruer and Klesper to rediscover the allotropic transformation in the upper austenitic range and to definitely prove the delta-gamma change in the alloys of iron with carbon and some other elements[27].

A further step toward establishing the nature of gamma-and delta-iron was furnished by the X-ray researches of Westgren and Phragmen[28]. X-ray photographs taken of an iron wire heated

at 800, 1100 and 1425 degrees Cent. (1472, 2012 and 2597 degrees Fahr.) have shown that at the former and at the latter temperatures, the iron has a body-centered cubic lattice and at 1100 degrees Cent. (2012 degrees Fahr.) a face-centered cubic lattice.

With reference to the atomic structure of gamma-iron, these researches in common with the evidence furnished by the Widmanstatten structure, show, that that structure is a face-centered one. They also show, that at temperatures investigated by Baykoff, the gamma structure persists.

When speaking on the structure of delta-iron, Westgren says: "The strange fact is thus proved, that the lattice transformation that takes place at 900 degrees Cent. (1652 degrees Fahr.) (A3) is reversed at 1400 degrees Cent. (2552 degrees Fahr.) (A 4)[29]. The author would like again to draw attention, how similar, even in wording, this statement is to that made by A. Wingham, when discussing Ball's paper in 1890; he puts it as follows: "The iron at very high temperatures, but below melting, changed again into a form having properties, which might be similar to those of the original modification."[25]

It follows that at high temperatures the atomic structure of iron is the same as below 700 degrees Cent. (1292 degrees Fahr.) and that only in the austenitic range the lattice is different. In other words, the primary dendrites of pure iron undergo an allotropic change in the upper part of the austenitic zone.

If the delta transformation could be traced further down from pure iron to carbon steels, the granulation process (in alloys cooled down from the melt) would be definitely linked up with the delta-gamma change. According to Ruer and Klesper, however, this transformation may be traced in low-carbon alloys only, and after 0.36 per cent carbon, ceases altogether (Fig. 11). It follows, as if in steels of higher carbon content, than the already indicated 0.36 per cent, the delta-gamma transformation would not play any part at all.

The author thinks, however, that what has been said in paragraph 2, with reference to the macrostructure of steel, might to a certain degree modify this contention. As stated above the non-homogeneity of the dendrites is a very seriously established fact; therefore in alloys considerably richer in carbon than 0.36 per

cent the influence of the delta-gamma transformation might still be felt and the subsequent structure influenced by it.

There is another consideration, which tends to show that the possible influence of the delta-gamma transformation on the granu-

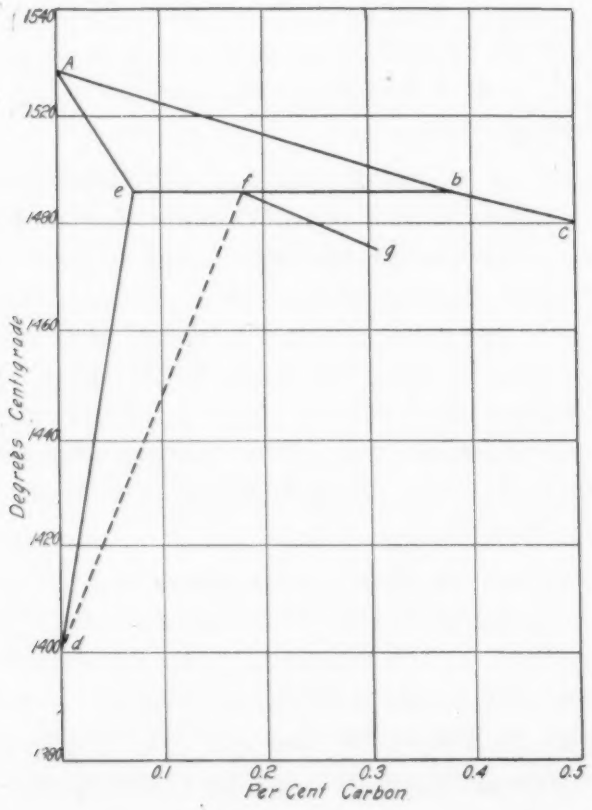


Fig. 11—Diagram showing the delta-gamma transformation in iron-carbon alloys. (After Ruer and Klesper).

lation process is not to be minimized, that is, the remarkable coincidence of equilibrium diagrams of the iron-carbon and the iron-nickel alloys. In both cases, under suitable conditions, a well developed Widmanstatten structure occurs; for example, that of the alloy No. 8 in the former and the meteorite structure in the latter.

As shown by the author elsewhere[30], the occurrence of Widmanstatten structure is facilitated in both cases by the previous *granulation*. On the other hand, as shown by the last researches of Hanson and Freeman[31], the delta-gamma transformation also occurs in the iron-nickel series (Fig. 12). So it appears, that

in the two cases most typical for the development of granulation, revealed by the Widmanstatten figures, a delta-gamma change is present.

On the other hand, there is one crystallographic consideration which appears to the author to be important, but which can not be fully accounted for; that is, the primary fact of the octahedral

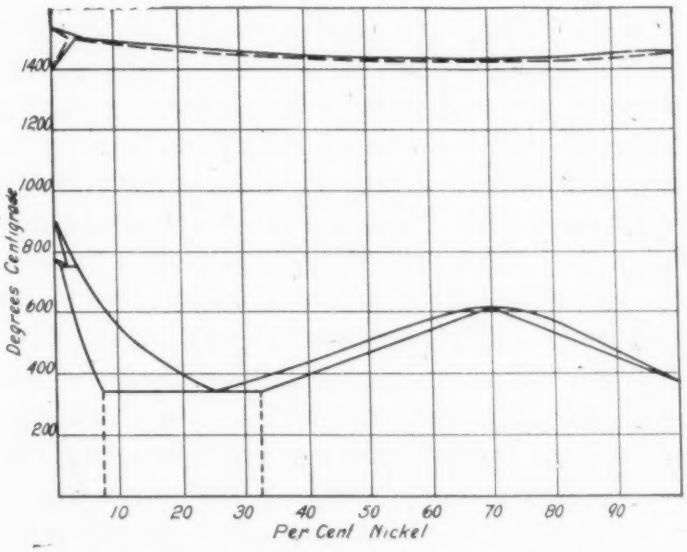


Fig. 12—Equilibrium diagram of iron-nickel alloys. (After D. Hanson and J. R. Freeman, Jr., 1923).

crystallization of the dendrites. In "pre-lattice" days, metallographers were unanimous in accepting the fact that dendrites and single crystals clearly revealed the octahedral structure of iron. Now, if we translate that in our "post-lattice" language, it will mean, that single crystals and dendrites crystallize in the face-centered cubic lattice, like gamma-iron. That, in turn, will bring us to the conclusion, that either delta-iron crystallizes in the face-centered lattice, or that there is no crystallographic difference in the structure of the dendrites and the granulae.

As, according to Westgren, delta-iron crystallizes in the cube-centered lattice, the first is not the fact. The second alternative, as discussed above, also does not fit in with the established fact of the general appearance in alloys, cooled down from the melt, of the network structure versus that of large crystals.

The author, therefore, suggests the following tentative explanation until new and conclusive evidence is brought to light;

in very low carbon steels dendrites of delta-iron may be supposed to separate from the melt and to crystallize in the body-centered lattice. On the lines of research of Osmond, these dendrites may be, further, supposed to be dendritic colonies, for instance, a row of cubes of the same dimensions, united by one face with coinciding centers[32].

In series of more than 0.36 per cent carbon the outer form of the dendrites will no longer be that of the cube, but of the octahedron as required by the face-centered lattice. However, as suggested above, the inner layers of the dendrites, even comparatively rich in carbon, would be of concentrations lower than 0.36 per cent and consequently, will undergo the delta-gamma transformation. Such transformation inside of the dendrites may account for a certain tendency for rearragement of molecules, or even of elementary crystalline elements, and would result in a certain "accommodation" between adjacent branches of interlocking dendrites, finally giving rise to crystalline volumes of more or less granular appearance. An explanation on these lines, while accounting for the influence of the delta-gamma transformation, also explains the reason that in the case of alloys cooled down from the melt, the size of the granulae is macroscopic and on the same scale as the dendrites. It might also account for the fact that the dendrites of very low carbon content are never well defined and never give the same sharp and regular outlines as in steels richer in carbon.

In closing these suggestions, the author would like to have it perfectly understood that they are only made with reference to castings and alloys cooled down from the melt. As to usually treated articles, the granulation process stands in no relation to the delta-gamma transformation, as then granulation occurs after reheating during cooling down from the austenitic range and is, consequently, a gamma-process in its pure substance.

## Summary

1. The dendritic structure, as revealed by macro-etching, is an extremely stable one. It persists under the usual heat-treatments, like tempering and quenching, and can be brought back, after a complete cycle of such heat treatments (N. I. Belaiew).

2. If the elements of secondary crystallization, ferrite and cementite, lodge themselves according to the symmetry of the

dendrites, a structure arises called the *structure of large crystals*. When examined by the unaided eye, it shows a complete identity of picture with the dendritic structure. Under the microscope the most characteristic feature is the *discontinuity* of the excess element (ferrite or cementite), which has segregated into pseudo-dendrites (cementite), or in small isolated islets (ferrite).

The structure of large crystals occurs either in steel very rich in carbon, or in single crystals, and therefore, is not of usual occurrence.

3. In usual steel articles or in most of slowly cooled specimens, the usual structure is the *network-structure*. The character and distribution of the meshes is the same in the former as in the latter; the difference is only in scale. Under the microscope this structure, in contra-distinction to that of large crystals, is characterized by the *continuity* of the mesh, and consequently, by the continuity of the outer shell of the excess element round the inner nucleus.

4. The Widmanstatten figures in the Widmanstatten structure are octahedral sections. They point to the octahedral cleavages of the inner crystalline mass inside the shell. Thence, that mass is an allotriomorphic crystal, and moreover, crystallizes in the face-centered cubic lattice. The author calls this crystalline grain—*gamma-grain or granula*. He calls *granulation* the process leading to its formation.

5. According to Osmond and Baykoff, the existence of the gamma-grain is to be traced up to 1120 degrees Cent. (2048 degrees Fahr.) in the austenitic zone. Consequently, the granulation process originates in the upper part of the austenitic zone.

In steel articles, usually treated, i. e. heated to a certain temperature in the austenitic zone and then cooled down at a certain velocity, the granulation process develops in function of the maximum temperature and the rate of cooling. The number and the size of the gamma-grains are governed by the Tammann laws for spontaneous and linear crystallization. According to various researches, among them those of Giolitti and the author, the mesh of the secondary element bears no relation to the orginal dendritic structure.

6. In castings and in slowly cooled steels, according to Giolitti and the author, the ferrite mesh still has no relation to the structure of the dendrites. But, owing to conditions of cooling, the number

of nuclei of recrystallization is small and the linear velocity is large. Consequently, the number of granulae is small, their size becomes large and the whole structure is macroscopic, generally, on the same scale as the dendrites. Therefore, sometimes, one mesh comprises several dendritic systems, and sometimes, cuts through one dendrite.

7. A granulation process, similar to that of steels, and similarly revealed by Widmanstatten figures, occurs in iron-nickel series in meteorites. In both iron-carbon and iron-nickel alloys a delta-gamma transformation has been discovered. In both series, the transformation occurs in alloys rich in iron. A suggestion is put forward by the author explaining, how the delta-gamma transformation might account for the occurrence of granulation in alloys cooled down from the melt.

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# MOLYBDENUM STEEL—SOME PRODUCTION DATA

By E. W. Pierce

*Abstract*

*The merits of molybdenum and chromium as alloying elements in structural steels, as compared with chrome-nickel steels, is the subject of this paper. A discussion of the physical properties of these two types of steel is included. Definite figures on the machining costs of chrome-nickel and chrome-molybdenum connecting rods are incorporated as the basis for determining the adaptability of these types of steels for automotive uses.*

*Heat treatment temperatures, Brinell hardness numbers, physical properties and microscopic structures observed, are likewise given.*

MOLYBDENUM as an alloying element in steel has been found to be of great advantage in a variety of grades of steel, both in high-speed steels and regular structural types. The value of molybdenum as an alloying element has been under discussion for some time and many tests, both laboratory and production, have been carried out to ascertain its merit.

In this discussion, a brief review of physical data will be given concerning the commercial types of molybdenum steel, including accurate and definite machining data which has been compiled from regular production tests. It is not the author's intention to enter into a discussion of the relative merits of the different steels as to their application in different automobile parts, except as noted above.

The manufacture of molybdenum steel will not be touched upon inasmuch as a great amount of data can be obtained on this subject elsewhere. Given a good uniform and homogeneous steel free from inclusions, we are directly concerned with its physical properties, its adaptability to structural design and the actual cost of production and fabrication.

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A paper presented before the Indianapolis chapter of the Society, April, 1924. The author, E. W. Pierce, is metallurgist with the Maxwell Motor Corporation, Newcastle, Indiana.

Molybdenum steel was introduced into our plant to be used in the production of connecting rods to bring about;

1. Cleaner forgings with less rejections,
2. Better heat treating,
3. Machinability at greater speeds,
4. Machinability with lower tool costs.

At the time of introducing molybdenum steel into regular production, a chrome-nickel steel, S. A. E. 3135 was being used. All connecting rods made of the molybdenum steel were treated to the same Brinell hardness as were those of the chrome-nickel type. At a given Brinell hardness, the molybdenum steels show higher physical properties.

This is better demonstrated by a series of tests made by C. N. Dawe[1] from which the following is taken.

| Steel | Temperature Quenched | Degrees Fahr. Drawn | Yield Point lbs. per sq. in. | Ultimate Str. lbs per sq. in. | Elong. in 2 inches per cent | Red. Area per cent | Merit index |
|---|---|---|---|---|---|---|---|
| Chrome—Molybdenum | 1550-1650 | 1000 | 147,900 | 157,600 | 20.3 | 57.0 | 72.0 |
| Chrome—Nickel | 1475-1575 | 1000 | 103,360 | 123,036 | 18.7 | 61.1 | 54.1 |
| Chrome—Molybdenum | 1550-1650 | 1100 | 118,500 | 131,900 | 24.0 | 64.4 | 84.3 |
| Chrome—Nickel | 1475-1575 | 1100 | 87,720 | 110,492 | 22.3 | 65.5 | 64.0 |

From these figures it is evident that the chrome-molybdenum steel has the higher combination of physical properties.

A second consideration must be given to the manner in which this steel can be handled. Forging, heat treating and machining are the main factors. To compete, this steel must, therefore, work as easily under the hammer and produce as clean forgings at usual temperatures as do the other types of steel. Also the heat treatments required, must be within the same working ranges. Then finally, the rate and manner in which the steel can be machined, determines its adaptability.

The figures compiled herewith are based on a production run of 23,000 connecting rods made of chrome-molybdenum steel figured against a production run of 112,000 connecting rods made of chrome-nickel steel. The analysis of the two types is as follows:

| | Specified Limits S.A.E. 4130 | S.A.E. 3135 | Actual analysis for chrome-molybdenum steel |
|---|---|---|---|
| Carbon ..... | .25 - .35 | .30 - .40 | .30 |
| Manganese .... | .40 - .60 | .50 - .80 | .40 |

1. *Journal* of Society of Automotive Engineers, January, 1922.

| | | | |
|---|---|---|---|
| Phosphorus .... | .04 | .04 | .015 |
| Sulphur ..... | .045 | .045 | .03 |
| Chromium ..... | .50 - .70 | .45 - .75 | .51 |
| Nickel ..... | | 1.00 -1.50 | |
| Molybdenum ... | .15 - .25 | | .24 |

Microscopic examination showed some slag, but to no greater extent than that of the average open-hearth steels.

## Forgings

From the entire heat of 88,000 pounds, there were no rejections at the shears for pipes, seams or surface defects and the steel was very suitable for forging. The steel flowed well under the hammer and freed itself from scale with the first blow. It had a somewhat wider heating range, thus reducing its susceptibility to burning. There were less rejections for forgings not filled out, and on the whole cleaner forgings were produced. In actual figures the rejection for forging defects was reduced from 5.5 to 2.6 per cent. The hammermen reported that this steel could be worked much more readily than the chrome-nickel steels. However, a longer period of time of heating was required to bring the steel up to uniform working temperature.

## Heat Treating

Very little trouble was experienced in the heat treating of this material. The treatments used were:

| | Normalized | Quenched | Quenching | Tempered |
|---|---|---|---|---|
| | | Degrees Fahr. | Medium | Degrees Fahr. |
| S.A.E. 3135 .. | 1600 | 1550 | Oil | 1180 |
| S.A.E. 4130 .. | 1650 | 1575 | Water | 1250 |

This heat treatment produced a good sorbitic structure. Brinell hardness number limits, after heat treating were 217-241, each rod being tested. The average rejection for the chrome-nickel steel was 11.7 per cent, and for the chrome-molybdenum steel, 10.8 per cent, thus showing a reduction of 8.0 per cent.

Difficulty was at first experienced with pickling, due to the fact that the acid would not remove the scale in the channels of the rods. This was overcome by using a special crate, and stacking the rods vertically, so that the scale would be entirely removed from them and settle to the bottom of the tank.

## Machining

The following figures taken from the more important operations, were based on machining 20,000 chrome-molybdenum and 180,000 chrome-nickel rods.

| Operation | Per cent Speed Increase | Life of tools Chrome-Nickel | Chrome-Molyb. | Average number of pieces per grind Per cent Increase |
|---|---|---|---|---|
| No. 2 Drill 17/32 inch .... | Normal | 48 | 53 | 10 |
| No. 2 Drill 17/32 inch .... | 7 | .. | 101 | 110 |
| No. 2 Drill 17/32 inch .... | 23 | .. | 77 | 60 |
| No. 2 Drill 17/32 inch .... | 29 | .. | 55 | 15 |
| No. 2 Ream 9/16 inch .... | Normal | 373 | 507 | 36 |
| No 2 Ream 9/16 inch .... | 7 | .. | 1,312 | 252 |
| No. 2 Ream 9/16 inch .... | 23.3 | .. | 1,065 | 185 |
| No. 2 Ream 9/16 inch .... | 29 | .. | 873 | 134 |
| No. 3 Bore (shell reamer) . | Normal | 71 | 203 | 186 |
| No. 3 Bore (shell reamer) . | 7 | .. | 644 | 807 |
| No. 3 Bore (shell reamer) . | 29 | .. | 370 | 421 |
| No. 8 Drill 13/32 inch .... | Normal | 16 | 67 | 319 |
| No. 8 Drill 13/32 inch .... | 34 | .. | 94 | 488 |
| No. 14 Tap 3/8 x 24 x 12 ... | Normal | 89 | 866 | 873 |
| No. 14 Tap 3/8 x 24 x 12 ... | 34 | .. | 1,264 | 1,320 |

| Operation | Difference in tool cost per piece. Per cent gain—Chrome-molybdenum | Difference in speed Per cent gain—Chrome-molybdenum | Per cent Increase Production |
|---|---|---|---|
| No. 2 Drill ..... | 14.6 | 29 | 26 |
| No. 2 Ream ..... | 127.8 | 29 | 26 |
| No. 3 Bore ..... | 411.2 | 29 | 25 |
| No. 8 Drill ..... | 494.0 | 34 | 9.5 |
| No. 14 Tap ..... | 1,318.0 | 34 | 9 |

From this machining data, the following machining-operation analysis is made. On drilling and reaming operations at an increased speed of 29 per cent, an increase in the number of pieces per grind was 15 per cent for drilling and 134 per cent for reaming. The boring of the large, or crankshaft, end was the most severe operation. On this job a shell reamer was used. At an increased speed of 29 per cent, there was an increase in the number of pieces per grind of 421 per cent.

On the drilling of the holes for the cap bolts, an increased speed of 34 per cent was used, with an increase of 488 per cent in the number of pieces per grind. Then on the tapping operation,

the molybdenum steel was very adaptable. At the increased speed of 34 per cent, an increase of 1320 per cent per tap was noted.

## Tool Costs

In comparing the tool costs on the e same operations, it is further noted that the gains for the molybdenum steel were 14.6 per cent for drilling, 127.8 per cent for reaming, 411.2 per cent for large shell reaming, 494 per cent for cap bolt drilling and 1318.0 per cent for tapping.

| | |
|---|---|
| At normal speed chrome-nickel S.A.E. 3135 per piece..... | .041051 |
| At 34 per cent increase speed chrome-molybdenum S.A.E. 4130 per piece ..... | .026275 |
| Net gain for chrome-molybdenum ..... | .014776 |

## Production Costs

The total amount of time required to do this machining was reduced 22 per cent. The exact figures are as follows:

| | | |
|---|---|---|
| Average cost per rod chrome-nickel | Direct labor.... | .06239 |
| Average cost per rod chrome-molybdenum | Direct labor.... | .04855 |
| Net gain direct labor per rod ..... | | .01384 |

In the straightening operation it was found, that the molybdenum steel bent much more easily than did the chrome nickel steel. To determine if possible, the cause of this difference, bend tests were made.

Deflection load curves were drawn from the results obtained in bending sample rods between two supports, 5 inches apart, with the web in the horizontal plane. These results are as follows:

| | Chrome-molyb. | Chrome-nickel |
|---|---|---|
| Bending moment at elastic limit in inch pounds ..... | 3,650 | 3,150 |
| Deflection at elastic limit ..... | 0.037 | 0.024 |
| Load applied at center at elastic limit in pounds ..... | 1,460 | 1,260 |
| Area of cross section at similar points in I-beam section in square inches (measured by planimeter)..... | 0.275 | 0.275 |

The molybdenum steel rods proved to be 16 per cent (500 inch pounds) stronger than the chrome-nickel rods, and deflected about 1/64 inch more before reaching its elastic limit.

As pointed out in a comparison of physical properties, the chrome-molybdenum steel shows a greater elongation or greater tendency to ductility, therefore it straightens more easily.

This data has enabled the writer to arrive at some definite and positive figures on actual machining costs in respect to molybdenum steels, and it is pointed out, that there is little doubt of the adaptability of molybdenum steel from a machining standpoint, as a means of reducing tool costs and direct labor costs.

# THE PRESENT STATUS OF MAGNETIC ANALYSIS*

By R. L. Sanford

*Abstract*

*The magnetic analysis of materials, for the determination of their physical properties, has been studied by many investigators for a considerable period of time. The author makes reference to the numerous types of testing equipment which have been developed in the study of special shapes and types of material, and has reviewed the history of magnetic studies of various investigators. He points out both the advantages and disadvantages of this method of testing and makes a plea for more scientists to enter this field of investigation.*

## Introduction

THE possibility of utilizing magnetic methods for the nondestructive testing of iron and steel, and their products, has long been a subject for speculation and experiment. The development of such nondestructive testing methods must of necessity be based upon certain definite laws of correlation between magnetic properties and other physical properties. The establishment of such definite correlations, however, requires the carrying out of a large amount of research of a fundamental nature. In view of the evident complexity of the subject and in the light of the unsatisfactory state of knowledge, even of the fundamental nature of magnetism itself, the apparent slowness in the development of such methods is not to be wondered at. The certainty that such definite relationships must exist, however, and the benefit which would result from the satisfactory solution of the problem give ample justification for the expenditure of a large amount of effort in this field.

In a paper presented before the American Society for Testing Materials in 1914, Dr. Mathews[1] concludes—

"Have we not maintained our thesis that the fascination of magnetic investigations lies in the frequency of unexpected results?

1. The numbers refer to the bibliography which appears at the conclusion of the paper.

*Published by permission of the Director of the Bureau of Standards of the United States Department of Commerce.

A paper by R. L. Sanford, physicist and chief of the magnetic section of the U. S. Bureau of Standards, Washington, D. C.

But unexpected results are not necessarily incapable of explanation. They are unexpected because we do not know the 'rules of the game,' and because our mental conceptions of the relationship between physical properties and magnetic properties are in error. There must be laws governing both. Can we discover them? Evidently our fundamental information in regard to the magnetic habits of steel and alloys is insufficient. Who will supply the missing knowledge? The author hoped to do so, unaided, but now recognizes the immensity of the task and contributes this mite in the hope that others will do likewise and that further investigations will be stimulated by the results herein recorded." In this statement Dr. Mathews struck the very keynote of the whole problem. It is becoming more and more apparent that we must improve our mental conceptions of the relationship between magnetic properties and other physical properties, and add much to our fundamental information in regard to the magnetic characteristics of iron and steel before much more rapid progress can be expected along the line of practical application.

Since the presentation of the paper just referred to, much progress has been made, as evidenced by the published results of numerous investigations and a number of practical applications, description of which have not appeared in the technical press. It would seem, therefore, that it might be worth while at this time to review briefly the progress of magnetic analysis during the past decade and to indicate in a general way its present status.

In 1916, Burrows[3] published a paper in which he gave an excellent resume of the work done up to that time on the correlation of magnetic properties and other physical properties. In the light of the results there recorded he states that the experimental evidence "seems to point to the conclusion that there is one and only one set of mechanical characteristics corresponding to a given set of magnetic characteristics, and conversely there is one and only one set of magnetic characteristics corresponding to a given set of mechanical characteristics." This oft' quoted statement aroused a considerable amount of interest in magnetic anaylsis which led in some cases to experimental investigations of a constructive nature, and in others to an attitude of "impatient expectancy" on the part of those who could readily appreciate the great

value of successful practical application but who had an inadequate conception of the magnitude of the task. It is to be regretted that this attitude has been fostered in some cases by extravagant claims not warranted by the evidence upon which these claims are based.

In discussing past progress and present status of magnetic analysis no attempt will be made to follow any chronological sequence but instead the subject will be treated under the general headings of (1) Methods of Measurement (2) Correlation of Properties (3) Thermomagnetic Analysis (4) Applications.

## Methods of Measurement

It is not within the scope of this article to describe the technical details of various methods of magnetic measurement. Some apparatus has been developed, however, especially to meet the needs of investigators in the field of magnetic analysis. The development of these methods, therefore, constitutes one element of progress along this line. In this connection, reference is made only to methods and apparatus for determining the magnetic properties of samples of material under laboratory conditions and not to apparatus devised for special purposes. These will be treated under the heading of applications.

For a number of years prior to the present development of magnetic analysis, the Burrows permeameter was considered the standard instrument for the magnetic testing of straight bars. This apparatus, however, requires two specimens of the same material and is very sensitive to any lack of magnetic homogeneity along the length of the sample. It also requires two adjustments to compensate for the effect of the yokes and is consequently somewhat complicated to operate, especially for the determination of points on the hysteresis loop. This condition led to the development of the Fahy permeameter[5], a compensated instrument requiring only a single sample and being less complicated to adjust than the Burrows. With this instrument most of the data on correlation of properties published by Burrows and Fahy[10] was obtained. This permeameter is capable of good accuracy but still requires compensation for satisfactory results. Fahy later brought out the Fahy Simplex Permeameter[8] which requires only a single speci-

men and no compensation. This instrument is much less complicated and more simple than the earlier type and has been used in a number of investigations. Several adaptations and modifications of this apparatus have been used in investigations on practical applications.

In many cases it has been found desirable to extend the range of magnetizing forces used in testing to values higher than those attainable by the usual methods. In order to meet this need a modification of the Ewing isthmus method was developed at the Bureau of Standards[18-19]. With this apparatus measurements can be made with magnetizing forces extending to 3000 gilberts per centimeter, which is generally sufficient to produce saturation. It requires a sample 6 millimeters in diameter and its application has thus far been limited to fundamental investigation.

In many cases, where alloys of exceptional purity or special composition are to be studied, only a small amount of material is available and consequently the ordinary types of apparatus can not be used. The high induction apparatus just mentioned will take a small sample but its accuracy is not satisfactory for values of magnetizing force below 100. In order to overcome this difficulty a "magnetic comparator" has been developed at the Bureau of Standards[27]. This apparatus yields satisfactory results on samples 6 millimeters in diameter and 10 centimeters long, thus requiring only about 25 grams of material.

The addition of these methods to the ones already available prior to 1914 should do much to facilitate the collection of correlation data of a fundamental nature. For an excellent description of the available methods of magnetic testing the reader is referred to a paper on this subject by Spooner[25].

## Correlation of Properties

The statement has been made that we need not await the establishment of the complex relationship between the magnetic and other physical properties of iron and steel before proceeding with the development of practical applications. This is true in a general way, but on the other hand, the extent to which magnetic methods can be utilized, ultimately, will depend largely upon the extent of our knowledge of the fundamental laws of correspond-

ence involved. For this reason active research of a fundamental nature is essential in order to realize in the fullest degree the possibilities of magnetic analysis.

A great many investigations have been carried out in the past for determining the effect of various influences on magnetic properties but it is only in recent years that systematic work has been done with the end in view of practical application in a commercial sense. It is also true that it is only comparatively recently that methods of magnetic measurement of an accuracy high enough to permit of the comparison of the results of different investigators on a quantitative basis have been available.

Studies on the effect of chemical composition are difficult owing to the great sensitiveness of magnetic properties to the structure and condition of the material resulting from its thermal and mechanical history. It is difficult even to put two pieces of material having the same chemical composition into such condition that their magnetic properties are identical. For this reason little has been done on chemical composition. An article by Ruder[2] and the work of Cheney[29] along this line do, however, indicate in a general way the influence of certain chemical elements on the magnetic properties of steel.

The effect of heat treatment on the magnetic properties of steel has probably been the subject of the greatest amount of work along the line of the correlation of properties. A paper by Burrows and Fahy[10] published in 1919 gives the main results of a joint investigation on spring steel by the Bureau of Standards and the Pennsylvania railroad. In this paper many experimental data are given, showing the effect of various heat treatments on several types of steel commonly used in the manufacture of springs. A study of the data presented brings out the close relationship between magnetic and mechanical properties of steel although no quantitative correlations were established. The results lead to the conclusion that any influence which causes a change in mechanical properties brings about a corresponding though not necessarily proportional change in magnetic properties.

The interpretation of the results of correlation experiments was carried a step further by Nusbaum[14], who pointed out that while the same value of maximum induction or residual induction might be associated with quite different mechanical properties,

it was possible by means of what he termed the "method of limiting values," to determine which of two states was indicated. This method involves the use of at least two magnetic characteristics to completely locate the material as regards the heat treatment.

Gebert[13] has correlated various combinations of magnetic characteristics with the results of mechanical tests on the same samples and finds linear relationships within certain rather narrow ranges. It appears, however, that whenever the heat treatment used to modify the mechanical properties caused a metallographic transformation in the steel, the relationship shows an abrupt change.

Probably the most logical approach to the problem of correlation of properties is through the use of the reluctivity relationship. This relationship was first suggested by Kennelly[38] in 1891 and has been discussed in some detail by Steinmetz[7]. This law, which holds above a certain minimum value of magnetizing force, depending upon the material, yields a linear relationship from which two constants can be derived which may truly be called magnetic constants. It is found that the metallic reluctivity $\frac{H}{B-H}$ increases linearly with the magnetizing force (H). As the line does not pass through the origin it is defined by its slope and its intercept on the reluctivity axis. The reciprocal of the slope of the reluctivity line is numerically equal to the saturation value of metallic induction (B-H), and the intercept, which indicates the rate of approach to this saturation value has been termed the "coefficient of magnetic hardness." This law holds good for pure homogeneous substances. If there are present more than one constituent, magnetically distinct, the reluctivity line appears to be composed of two or more straight portions having different slopes and intercepts. This gives a method, then, of judging of the degree of homogeneity of the specimen. It has been found[21] that a similar relationship connects the residual induction and the coercive force with the maximum magnetizing force used in their determination.

The use of the reluctivity relationship for correlation purposes is well illustrated in the work of Nusbaum, Cheney, and Scott[20], Nusbaum and Cheney[24], and Cheney[29] . It has since been used at the Bureau of Standards in a study of the effects of stress on magnetic properties. In this latter connection it appears that it

may be possible to use the relationship in a quantitative way. A paper describing this work is now in preparation.

The effect of stress has long been recognized as a disturbing factor in attempts at correlation. Many writers have called attention to this factor but it is doubtful if the magnitude of the effect has ever been fully appreciated. The effect of stress is especially notable at moderate values of magnetizing force such as have been used for the most part in correlation experiments. A comparatively low value of tension, for instance, is capable of doubling the magnetic permeability in some cases, where the effect which it is wished to study may be a relatively small percentage.

It should be evident from the foregoing that scientific research of the highest order is necessary for the untangling of the apparently complicated relationships between the magnetic and other physical properties of iron and steel. It is only reasonable to expect, however, that the effort required will be amply repaid not only in terms of practical application but also in terms of valuable fundamental knowledge which should aid greatly to improve our somewhat hazy ideas of the ultimate nature of ferromagnetism.

## Thermomagnetic Analysis

One line of investigation which would appear to be capable of yielding much valuable information regarding the structure of materials as affected by heat treatment, but which has received little attention in this country, is thermomagnetic analysis[9]. The technique of this type of investigation has received considerable development at the hands of the Japanese investigator Honda[39] and his associates. It consists in the determination of changes in magnetic properties which take place during heating or cooling. It has been found that the presence of definite chemical compounds in steel is indicated by more or less abrupt changes in magnetization as certain temperatures are reached during heating or cooling. These temperatures correspond to the magnetic transformation temperatures of the compounds in question. This line of investigation deserves much more attention than it has received, as its use would greatly aid in many investigations, especially in connection with the phenomena involved in the heat treatment of steel.

## Applications

It is exceedingly difficult for any one individual to discuss magnetic analysis adequately from the standpoint of practical applications. Much of the experimental work that has been done along this line has not been described in the technical press. A glance at the relatively few articles which have appeared, however, will serve to indicate the great variety of materials and products which have been the subject of investigation. Rails, cutlery, ball bearing races, ball bearing balls, saws, springs, welds, drills chain, and rifle barrels are among the products upon which much work has been done, and it is known that many other products have been studied by magnetic methods. It is obvious that with such a variety of objects, each application must be the subject of individual investigation. Not only is a great range of materials represented but also the great variety of shapes to be tested necessitates the development of special testing apparatus in each case.

One of the most serious dangers in steel structures is the existence of flaws and imperfections in otherwise satisfactory, material. The presence of such defects has been known in many cases to result in the failure of structures which with perfect material would have had ample strength. In order to discover flaws and imperfections a nondestructive method is needed which can be applied to either the raw stock or the finished product, or preferably to both. The possibilities of magnetic analysis in this connection were early realized and methods for detecting flaws have received considerable development.

Intensive work along this line was started at the Bureau of Standards in connection with some tests of rails which had failed in service. Although these first tests by magnetic methods were unsuccessful, they led to an investigation of methods for determining the distribution of magnetic leakage along the length of a specimen of uniform section. This principle of magnetic leakage measurement has been utilized by Burrows[3] in the development of a method for exploring rails. The technique of magnetic leakage exploration has been developed to a high degree of perfection and has been applied to the examination of rails[12], raw material for rifle barrels[16], springs[26], and wire rope, besides a number of other applications which have not been described in any publications.

The methods of leakage measurement are extremely sensitive and indicate very slight variations in magnetic quality along the length of a specimen. They are consequently particularly sensitive to the effects of stress. This condition leads to the result that non-uniform stress distribution may cause much greater magnetic indications than the flaws which it is wished to detect. Until this difficulty is satisfactorily overcome it seems probable that this method will be somewhat limited in its application.

Experiments looking toward the development of practical testing methods on a commercial scale have covered a large variety of products. In general it has been found that magnetic methods are of value, especially in the hands of experts trained in the principles of magnetic testing. At the present time, however, the laws of correlation have not been sufficiently established to permit of reducing such testing to a formula.

Perhaps an outstanding example of research on practical application is the one now under way by the American Society for Testing Materials Committee A-8 on Magnetic Analysis. A subcommittee was organized in 1920 to study the possibilities of magnetic analysis for the testing of twist drills. This subcommittee numbered among its members a steel manufacturer, a manufacturer of twist drills, and several magnetic testing engineers. The experiments were planned with great care. The drills were made under carefully controlled conditions, tested by magnetic methods by various members of the committee and finally subjected to a series of carefully devised cutting tests. A progress report of the committee[37] states that so far as the correlation of properties was concerned, the results were for the most part negative. One method of testing, however, was brought out which seemed capable of further development and the experiments are being continued. The results of this investigation should not by any means be considered as discouraging. Much was learned of the effect of various treatments on magnetic properties and a new method of testing which is worthy of special note, was evolved. This method involves the use of alternating currents and seems to offer many advantages especially from the standpoint of commercial use. It has been described by deForest[30-31] who has used it, not only for drills but for other purposes. The use of alternating current requires the development of a new technique,

but if it fulfills its present promise, results should amply justify the effort.

There is space to do little more than mention the other applications which have been attempted. The balls[36], and races[15] for ball bearings, cutlery and small tools[10], welds[28], saws[44] and wire rope[34-35] have all been the subject of investigation, to say nothing of many other products not mentioned in the technical literature. Each one of these investigations has yielded data of considerable value which should be utilized in the further development of magnetic analysis.

## Conclusion

From a consideration of the foregoing rather sketchy review of the subject of magnetic analysis it should be apparent that, especially considering the relatively small number of workers in this field and the great mass of data which must be obtained and interpreted, the progress during the past decade has indeed been substantial.

Magnetic testing apparatus has been developed capable of sufficient accuracy to permit of comparing, quantitatively, the results of different investigators.

The close relationship between the magnetic and other physical properties of iron and steel has been demonstrated as a general principle.

Many data have been presented which give a good idea of the general nature of this correspondence.

A number of applications to industrial problems have been made which have definite commercial value.

The subject is still in the investigational stage but more rapid development is logically to be expected in the near future.

More investigations of a fundamental nature are necessary if full advantage is to be taken of the correlations which it seems certain must exist.

The application of the thermomagnetic analysis should be developed, as it appears that this method of investigation is capable of being quite useful in the study of the treatment of iron and steel.

The outlook is more than promising. The achievements already recorded give ample justification for the expectation that, when

the fundamental principles are more fully understood, methods of research and testing will be developed whose value can hardly be overestimated.

The real pressing need is for more workers and closer co-operation if the best progress is to be realized in the next few years.

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# COLD ROLLED STRIP STEEL

By Malcoln Farmer

*Abstract*

*This paper covers in some detail the production of cold-rolled strip steel, discussing the numerous factors which enter into the manufacture of this product. The author discusses casting temperatures, the segregation of elements within the ingots, the rolling of ingots into billets and slabs and the high speed rolling of billets, pickling, and subsequent cold rolling operations. A brief review of the various grades of cold tempered strip steel is given. Strips for special types of work are likewise discussed.*

THE manufacture of cold rolled strip steel is a well defined branch of the steel business of the country, and is to a large extent a specialty line of product. A fair idea of the growth of this particular industry during the past few years may be had by listing the mills producing cold rolled strip steel. In the year 1916 there were 20 cold rolled strip mills in the United States, with an annual capacity of 700,000 tons. At the present time there are some 42 mills with a capacity of approximately 1,400,000 tons a year.

Flat steel was first cold rolled about 1871. The objective desired was steel that would be hard, and therefore easy blanking; also a cheap method of getting a bright finish for subsequent plating. At that time, cold rolled steel was used almost entirely for the manufacture of hardware such as planished door butts and hinges. Since then, a great deal of development has taken place and cold rolled steel is produced in various degrees of hardness and several finishes, which are adapted to an almost unlimited number of manufactured articles.

Most of the strip steel cold rolled is of the soft open hearth quality, with a carbon content running from 0.08 to 0.12 per cent. Higher carbon steels are also cold rolled in considerable quantities, as well as alloy steels, such as chrome-vanadium, low-carbon chrome, manganese, silicon, etc.

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A paper presented before the Hartford chapter of the Society. The author, Malcolm Farmer, is vice president of the Stanley Works, New Britain, Conn.

In making low carbon steels in the melting furnaces, particular care must be taken to see that the heat is not over-oxidized, and that undue segregation of carbon does not take place in the ingot molds. Such steel will be absolutely unfit for cold rolling and subsequent cold working in the dies.

## Segregation of Elements

Carbon segregation frequently occurs around the center of the ingot, due to the fact that this portion is the last to cool. Carbon, phosphorus and sulphur are impurities, having a lower solidifying point than iron, and are not as soluble in solid steel as in liquid steel. There is, therefore, a tendency for these impurities to separate as the steel solidifies in the ingot mold. The ingot cools from the outside in, and as each layer freezes, some of its impurities are given off, to be redissolved by the liquid steel nearer the center. It follows then that the last portion of the ingot to solidify is richest in impurities. This portion last to cool, is in the center just below the pipe or cavity left by the shrinkage of the metal from liquid to solid. This portion when rolled down to a billet, shows the same segregation and is carried along to the hot rolled strip and cold rolled steel. Segregations will show up sometimes in a strip four or five inches wide, wherein a carbon content of about 0.07 or 0.08 per cent will appear on the edges, and as high as 0.18 or 0.20 per cent in the middle. A 0.20 per cent carbon steel will not stand the same bends and cold working as a 0.08 carbon steel. Therefore, a strip of this segregated nature will probably fail in cold working.

## Casting Temperatures

The casting temperature of the steel is also of great importance. Low carbon steels if poured into the molds too hot, will tend to show injurious segregation of carbon. Also, the more fluid the metal, other things being equal, the nearer will be the blowholes to the surface of the solid ingot. These blowholes when very near the surface are often exposed during the reheating and rolling operations, and form seams or cracks in the surface of the strip. Blowholes so exposed to oxidation will never heal or weld. Steel cast at too low a temperature will solidify so quickly that op-

portunity is not afforded for the dissolved gases to escape, and an unusually large number of blowholes will result. A reasonable number of deep seated blowholes are not injurious, inasmuch as the normal gases included are reducing in effect. The surfaces of these holes being nonoxidized, will readily weld during the pressure of hot rolling.

A simple way to test the bath for tapping temperature, is by immersing a stirring rod or steel bar in the bath. If this bar is melted off short or square, where it enters the molten steel, the heat is "hot"; if it melts with a point the bath is "cold."

## Billets and Slabs

The cast steel ingots when stripped from the molds are reheated to about 1800 degrees Fahr. and rolled down in a blooming or billet mill to billets or slabs of the desired cross section. These are known as semifinished materials. Billets in general are considered as having a cross section of from 4 to 36 square inches, the width never being equal to twice the thickness. Slabs are rectangular in cross section where the width is at least equal to twice the thickness.

These billets or slabs are delivered from the mill in pieces from 40 to 70 feet in length, and are sheared into lengths which will give the desired weight of strip in one piece. During the shearing, care must be taken to crop back, or cut off enough from the ends to remove all of the pipe or hollow portion of the ingot formed when the molten metal solidifies in the mold. As this piped portion of the ingot is not sound steel its use will cause trouble in the hot mill, resulting in the splitting of the billet.

## High Speed Rolling of Billets

The steel is again reheated in billet form and hot rolled into strips on a high speed mill. These mills operate at 1000 to 2500 feet per minute, according to the type of mill and sizes rolled. The greatest number of passes through the rolls are on the flat side of the billet, that is, the metal is reduced in thickness, but there must also be edging passes to smooth up the edges and hold the strip to the specified width. Edging cracks off the scale which forms between passes. On rolling steel hot, there is considerable

spreading or side flow of the metal, and the man who is responsible for setting the rolls, both for width and thickness of the strip, has a very exacting job, and should he fail to do it properly, no end of trouble will follow. He must be careful to allow for spread. His guides must be so set as to deliver the bar from the rolls straight, but still not so tight as to cause scratches. The steel should not be allowed to pull or stretch between the mills, as this will give uneven width. The reductions should be uniform and the rolls must be set tight endways, otherwise snaky or crooked strips will be produced. The rolls should be changed often enough to keep a smooth surface on the strip, because if allowed to get too rough in the early passes, slivers on the steel will result. Rolled-in scale is often due to rough rolls.

The strip on leaving the mill is wound up on a reel like a ribbon, and becomes a coil or hoop, and is the raw material used for cold rolling. These coils will vary in weight from 50 to 1000 pounds each, the average weight of coil being 150 to 200 pounds. Coils as heavy as 1000 pounds are rolled only on one or two mills in the country.

## Pickling

The first step in cold rolling is the opening of the coil, and recoiling it with the bend in the opposite direction. This loosens and cracks off a great deal of the blue scale or oxide of iron $Fe_3O_4$, which has formed on the strip on cooling down from the hot mills. This recoiling is quickly and efficiently done on specially designed machines. The coil then goes to the pickling department. The pickling is effected by immersing the coil in a bath of sulphuric acid and water (about 10 per cent sulphuric acid), heated to about 190 degrees Fahr. This pickling removes all of the scale in about 20 minutes. The sulphuric acid attacks the steel and forms a sulphate of iron which is soluble in water and is washed off. The bath should be agitated to facilitate the pickling. The steel is then washed in cold water, and dipped in a hot soapy water bath. This leaves the steel free of scale, clean and of a grayish color.

The strips are then transferred to the breaking-down mills, usually set up in tandem, that is, two, three or four stands of rolls placed one after the other a few feet apart. The coil now cold,

passes through these mills, which are set to run at an increasing rate of speed from the entering mill to the delivering mill. For example, in a tandem mill of four stands of rolls, the entering mill might roll at the rate of 40 feet per minute, the delivering, or fourth mill would roll at a speed of 150 feet per minute. On leaving the mill it is wound up in a coil again. The rolls in these mills are ground smooth and bright, and the steel comes from them bright and clean. The reduction of from 30 to 50 per cent has hardened the metal so that it is stiff and springy. During this rolling all unevenness in the gage of the hot rolled strip is taken out, and the width has been increased only slightly, possibly 1/32 of an inch. A considerable amount of heat is generated in the steel during the cold rolling, so that it is often too hot to handle without the use of heavy gloves. Before further reduction is given the steel, it must be annealed to relieve the working strains set up within it, as well as to soften it.

## Annealing

The annealing is effected by packing the coils or strips on a heavy cast steel base or truck, and covering the pack with an air tight steel hood which is sealed all around the base with an ample sand seal. The truck is then pushed into a furnace and heated for about 12 hours, the furnace temperature being about 1450 to 1500 degrees Fahr. The truck is then allowed to cool outside of the furnace. A reducing gas, free from oxygen and moisture, is introduced into the hood, in order to keep the steel from oxidizing or discoloring during this operation. Time and temperature are the two important factors. Heat penetration in the steel goes on at the rate of approximately one inch per hour.

During this operation, care must be taken not to decarbonize the steel by excessive heat in hot spots in the furnace. Also if the gas used inside of the hood contains hydrocarbons, it will carburize low carbon steel at 1500 degrees Fahr. To illustrate these points, it has been shown that steel containing 0.25 per cent carbon before annealing, has contained only 0.12 per cent carbon after being annealed; also, a steel containing 0.10 per cent carbon before annealing has shown 0.50 to 0.60 per cent carbon afterward. Ordinary illuminating gas usually contains hydrocarbons such as ethane or methane, which make it an undesirable reducing medium.

Steel annealed in cast iron borings will also pick up carbon at fairly high temperatures.

The steel is allowed to cool for 36 hours under gas before the hood is removed, and is then in what is known as the dead soft or annealed condition, and is ready for further reduction in thickness (tempering or temper rolling).

## Temper Rolling

In cold rolling for temper, single stands of rolls are used. The rolls are highly polished and impart to the steel the high polished surface which is common to cold rolled steel. The rolls used are made of forged and hardened alloy steel, having a scleroscope hardness of 100. The manufacture and hardening of these rolls is an art, and if not properly done the roll is useless. The writer has seen a new roll fly apart on the second or third strip rolled through it, due to the strains set up in the roll during the hardening. In this finishing rolling, it is often necessary to grind one of the rolls, (usually the top) either slightly concave or convex, in order to bring the strip steel out flat. This concavity of "shape" as it is called may be only 0.0005 inch deep or as deep as 0.003 or 0.004 inch, and may be only wide enough to extend over part of the width of the strip. Without these "hollow shapes" or special grindings the strip may come from the mill buckled or high in the center, showing that it has been reduced in thickness more at that point, and consequently elongated more in the middle than along the edges. Sometimes a "high shape" or convex grinding is needed. In such cases the steel would come from the mill, wavy at the edges and flat along the center. The convex shape is so ground on the roll as to reduce the metal more in the center than at the edges. This elongates the center enough to match the length of the edges and the steel will then lie flat when rolled out on the floor. It requires a large amount of experience and good judgment to determine just how much, hollow or high, to grind a shape to bring a certain lot of steel flat. It is the practice in some mills to burn a gas jet under the bottom roll to expand it at desired points and so accomplish the shape. This is not good practice, however, as it is not as certain or accurate as grinding, and is very bad for the roll. Makers of good steel rolls will not guarantee or replace defective rolls that have been so

treated. The various tempers of the finished cold rolled strip steel are obtained by varying the amount of cold rolling after annealing. The tempered strip is then taken to the slitting and cutting department to be cut to the length required. In the case of orders calling for accurate width the strip must be slit and held to an accuracy of ±0.01 inch of the width ordered, except where the thickness is 0.095 inch or heavier, when a greater tolerance is allowed.

### Surfaces and Dimensions of Strips

Cold rolled strip steel must be clean, bright, flat and straight, when finished. The gage or thickness must not vary more than 0.002 inch under and 0.001 inch over the gage ordered for ordinary widths and the lighter gages. These limits are standard but closer rolling may be done, for which an extra charge is made.

The standard limit for straightness is ½-inch bow or camber in eight feet of length. Perfectly straight steel may be produced but an extra charge is made for limits closer than the standard.

Cold rolled steel is also produced with a smooth-rolled round or square edge, which is obtained by rolling the edges and flat surface in a universal type mill. This steel is for special uses. Strip steel may be cold rolled as thin as 0.002 inch. However, such rolling is not common. Strips 0.006 inch thick are not unusual. Finished widths may be had from ¼ to 30 inches.

### Degrees of Cold Tempering

If a free, clean blanking steel is wanted, a hard or No. 1 temper is used. This temper will cut clean, and will be easy on the punches and dies, as a reasonable clearance may be allowed. Temper No. 1 will also have a higher tensile strength than the softer grades. It will not, however, stand more than easy rounding bends crossway of the grain. The steel is hard rolled, unannealed and is recommended for flat work only.

Temper No. 2 or half hard steel, is cold rolled, annealed and rerolled. It will stand right angle bends across the grain and rounding bends along the grain.

Temper No. 3, or quarter hard steel, is cold rolled, annealed and rerolled a little less than temper No. 2, and will stand a bend flat on itself across the grain, and a right angle bend along the grain.

Temper No. 4 is rolled less than temper No. 3 after annealing, and will stand bending flat on itself either way of the grain. Steel of this temper is used for forming tubing. It is soft and still will not wrinkle when bent slightly. In order to draw a shell with a flat bottom, which will be smooth and show no cross wrinkles, this temper should be used.

Temper No. 5 is dead soft, annealed and not rolled after annealing. This is used for ordinary drawing and forming.

Temper No. 6 is also dead soft, but will stand more difficult drawing. It receives a special heat treatment and is of selected quality steel.

There are intermediate tempers which vary slightly from those given above, and are produced to suit certain requirements where a standard temper has not quite filled the bill; such as, buckle temper, tack head steel, and steel to draw up a shell and leave the edge even all the way around and not be wavy so that it requires trimming. This grade of steel is used for rollers for casters, and roller stakes.

## Strips for Special Work

In ordering steel for special work, a sample or sketch of the article to be made should accompany the order to assure receiving the proper steel for the work. The mill operators will undertake to specify the proper temper and guarantee the steel to form the piece designated. Often steel fails to do what is required of it, although through no fault of the steel. Sometimes the drawing tools have too much clearance, or perhaps too little; too large a radius or too small; the dies are allowed to become rough; the best kind of lubricant is not used; or the speed of the press is not right; usually too fast. Sometimes the hold-down does not hold the metal evenly and the blank slips, or it holds too tightly. The drawing solution if too heavy, will not permit the steel to draw up smoothly. To show the effect of improper lubricant, the writer will cite a case where a difficult draw and forming in one operation was being done. Steel would build up on the die, causing deep scratches on the formed piece, as well as having some pieces break in the drawing. A set of polished dies would not form more than 1000 pieces without scratching. By changing the lubricant from an oil compound to a solution of smooth lime, the breakage

stopped and one set of dies formed as high as 80,000 pieces without scratching.

Some years ago trouble was experienced with steel used for bells and gongs. When the gong or bell was formed it would not ring. This was caused by strains being set up in the steel during the forming which required subsequent aging or heat treatment to relieve the strains. When this was accomplished gong properties were restored. Since then a special steel has been furnished which requires no aging or heat treatment.

Fine quality cold rolled strip steel can only be produced by employing most careful methods, close inspection during the process of manufacture, and testing for workability by modern testing machines. It is most essential to start with the proper grade of raw material.

## DISCUSSION OF H. B. KNOWLTON'S PAPER ENTITLED "CASE HARDENING AND OTHER HEAT TREATMENTS AS APPLIED TO GRAY CAST IRON," PRESENTED BEFORE THE FIFTH ANNUAL CONVENTION OF THE SOCIETY, PITTSBURGH

PAPER PUBLISHED IN OCTOBER, 1923 TRANSACTIONS

CHAIRMAN A. H. d'ARCAMBAL: I will venture to say that nine men out of every ten in this room never knew before that such a thing could be done as to case harden or carburize cast iron. I would like to ask Mr. Knowlton one question. What hardness did you obtain by quenching directly in the oil, without carburizing?

H. B. KNOWLTON: Heated in sand at 1700 degrees Fahr. for 3 hours, quenched in oil, was 62 hardness. Heated and quenched directly, without long exposure of heat, was 68.

CHAIRMAN A. H. d'ARCAMBAL: The reason I asked the question was because a couple of months ago I received a circular—I will not give the trade name—but under it were the words, "The Magic Dip." Now you people have probably seen some of these most interesting circulars making remarkable claims. This circular stated the substance was a kind of liquid which you placed in the oil in which you were going to quench the iron and the resultant product would give you a hard iron, with the toughness of steel, so I was just wondering what happened when you quenched directly in the oil without this "Magic Dip?"

H. B. KNOWLTON: Also, when you take the thin sections like I had here and put them in a vise and hit them, you have about six of them left. I did not have the "Magic Dip," but that is just the ordinary oil treatment.

CHAIRMAN A. H. d'ARCAMBAL: I was curious to see what this "Magic Dip" was like, but having the interests of my company at stake, I thought I would write for the price. They wanted $25 a gallon for it, which price we considered excessive.

S. P. ROCKWELL: A number of years ago we carburized snap gages made of gray cast iron. They were cooled in the pot, but when they were quenched, they cracked. We packed them in mill scale and then malleableized them and subsequently recarburized them, with satisfactory results.

H. B. KNOWLTON: I have seen malleable iron case hardened before, but I had never seen gray iron carburized.

CHAIRMAN A. H. d'ARCAMBAL: Did the mixture you use have any steel in it, or was it ordinary gray iron?

H. B. KNOWLTON: One of these was called "foundry run

gray iron" and the other "special cylinder iron." I think there is a little steel in both of them, but very little.

CHAIRMAN A. H. d'ARCAMBAL: We ought to have considerable discussion on this very interesting subject.

JEROME STRAUSS: We have frequently used tools made of cast iron of three-quarters to one per cent silicon, and three-quarters to one and a half per cent manganese which, after rough machining, were hardened directly in oil or water without any attempt to carburize or prevent decarburization of the surface. After hardening, we removed a small amount of metal, and have had decidedly successful results in some cases. We were getting a scleroscope hardness of about 70 to 85. These were press tools for heavy press work.

CHAIRMAN A. H. d'ARCAMBAL: That was ordinary gray iron to start with?

JEROME STRAUSS: It probably would be classed as semisteel, there being about 10 to 20 per cent steel in the cupola mix.

CHAIRMAN A. H. d'ARCAMBAL: What temperature would you use for quenching?

JEROME STRAUSS: Approximately 1650 degrees Fahr. They were mostly, of course, heavy sections, running about 1½ to 3 inches.

H. J. FRENCH: I have been very much interested in this paper, particularly because in the last few months I have encountered this same question. It was presented to me by a western manufacturer, and from the author's discussion of the reasons for his undertaking this work, I judge that it is the same case with which he is dealing. I am sorry that I did not have an opportunity to examine the manuscript.

There is one question which comes up in my mind, and about which I would like to ask a question. I am not quite convinced that it is proper to refer to this heat treatment as a carburizing or even a case hardening, action. I would like to ask whether it is not possible to produce the same results without imbedding the samples in a carburizing compound. In other words, is it not possible that a surface reaction between the compound and the metal might promote diffusion? Now if that was so, it would be possible, of course, under different time and temperature relations, to produce a similar result, merely taking care to keep oxygen or air away from the sample. I wonder whether the author has ever tried a similar treatment, and whether he obtained results similar to those mentioned by Mr. Strauss.

H. K. BRIGGS: The author has mentioned the possibility of an increasing of the saturation point for carbon over that for the given silicon content by the heating cycles noted. Is not the test of the cause of that action whether or not your total carbon remains the same after treatment as it did before? If your total carbon has increased, it has evidently taken on some carbon from the carburizing compound about the surface. I would like to inquire as to what the analytical results showed.

H. B. KNOWLTON: Analytical results were not obtained on this test. I have them on another test that I have just started. This was on a bar about half inch by three-quarters by six inches long. The carbon on the original is 3.42 per cent. After running in the carburizing compound and cooling, 0.010 inch was milled off of each side. The chips from this operation were analyzed. They showed a total carbon of 3.75 per cent. Any chemists that are here who have run total carbon on a cast iron know that it is a thankless job. It is difficult to get a perfectly fair sample, because the graphite and the iron separate, and there is room for error. I am not putting these figures into print until I have a chance to verify them a number of times. Apparently the total carbon increased.

CHAIRMAN A. H. d'ARCAMBAL: Mr. McCleary, have you ever conducted any tests at Dodge Brothers on carburizing cast iron?

F. C. McCLEARY: No.

W. F. GRAHAM: I would like to ask the speaker if he has considered the fact that malleable iron when annealed sometimes shows a pearlitic skin, and that is certainly not carburized, or heated in a carburizing atmosphere. I hold with Mr. French, that the effect is the result of diffusion rather than an actual carburization of the material. When you anneal malleable iron, a pearlitic structure is formed of about the same type as would be formed in heating the cast iron.

CHAIRMAN A. H. d'ARCAMBAL: Mr. Knowlton was very careful to state that he did not call the process carburizing, for I think he knew that you fellows would criticize him.

W. D. FULLER: May I ask, just as a matter of information, how you obtained the last polishing effect on the cast iron.

H. B. KNOWLTON: The last polishing for microscope was just an ordinary proposition of working down with alumina and rouge.

W. D. FULLER: I found that had a tendency to smear the surface, and I wondered if you had a better method.

R. S. ARCHER: This remark on the malleable iron I think is very pertinent. All the causes of the formation of the pearlitic rim are not known, or at least they are not agreed upon. It is sometimes attributed to the somewhat questionable fact that in a very slow cooling there is enough difference in temperature between the surface and the inside of a casting to produce a difference in structure. There is another explanation offered that depends upon the oxidation of silicon. I think that may be one of the causes for the thing that Mr. Knowlton is getting here; that is, with a low temperature the silicon oxidizes in preference to carbon. There may be an oxidation of silicon in the iron, especially near the skin, which converts it into an oxidized, and therefore, inactive form, that is, to a form which is not active in reducing the solubility of the carbon. The silicon also raises the criti-

cal temperature approximately 20 degrees Cent. for each per cent of silicon. That is, if 725 degrees Cent. is the equilibrium hardening temperature for pure iron carbon alloys, then each one per cent of silicon raises that temperature about 20 degrees. Therefore, with 2½ per cent of silicon that temperature would be about 775 degrees. Now if you heat in a carbonizing medium and then reheat to a temperature of about 790 or 800 degrees, you would have a hardening temperature that would harden the entire casting. But suppose you heated to a temperature of 770 degrees Cent.; the temperature would not be high enough to harden the casting unless the silicon had been converted to an oxidized form. Therefore, if by heating it in a carburizing medium, you can convert the silicon in the outer layers of the casting to an oxidized form, you might thereby lower the critical temperature of the outside layer so a subsequent reheating would harden the outside, but would not harden the inside. In that way you might get true case hardness.

Mr. Knowlton mentioned that in some of the samples he observed a rounding or a spheroidizing of the graphite. I believe that has been reported before. I know I have seen it before—I am not quite certain where, but I think in a paper by Mr. Bean of the Eastern Malleable Iron Co., delivered before the American Institute of Mining Engineers. It has been found recently in a large number of alloys that almost any constituent whatever is rounded by prolonged heating. It depends upon the solubility of that constituent in the matrix. It is well known in the case of cementite in iron. It has been found in the case of copper oxide in copper, and has been found in the case of thorium dioxide in tungsten.

(Written discussion)

H. B. KNOWLTON: In the discussion of the writer's paper Mr. French and others raised a question as to whether the carburizing material had any part in producing the results mentioned. The question was raised as to whether or not the same results could have been obtained if the specimens had been packed in sand.

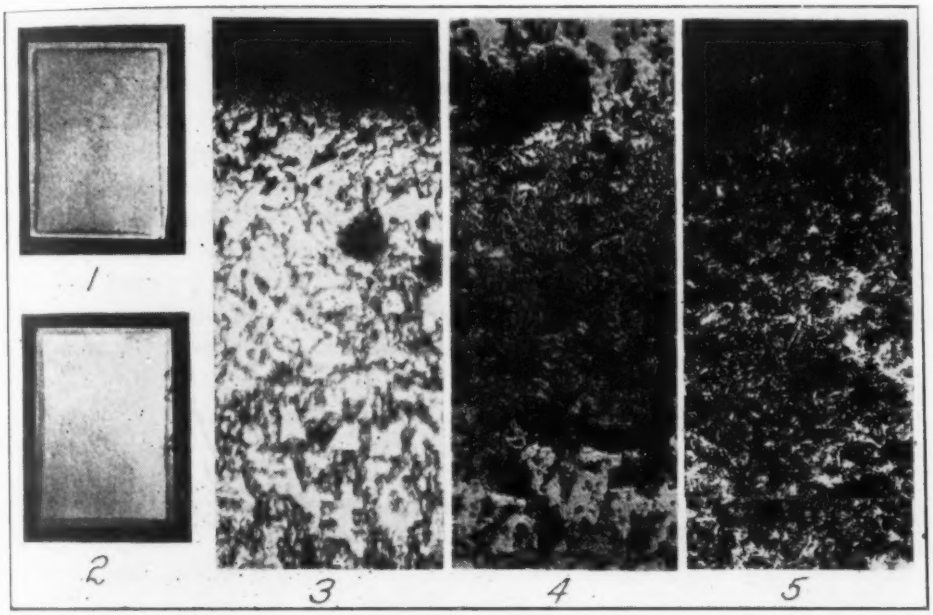
In order to answer this question the writer has made a test with two more bars of cast iron. One of these was placed in a container with a carburizing material and the other packed in a similar container with sand. Both containers were sealed in the same way and placed in a furnace and run for 8 hours at 1700 degrees Fahr. They were then allowed to cool in the furnace. When cold they were sectioned through the center, polished, etched and examined through the microscope.

The results produced are clearly shown in the accompanying photographs. Figs. 1 and 2 show a photograph of cross sections of the two bars after polishing and etching. Fig. 1 was the one which was run in sand. The so-called "picture frame" structure will be observed. It will be noted that there is a white border around the edge, and just

inside there is a dark band running all around the specimen, parallel with the edge. The center is light.

The specimen shown in Fig. 2 was packed in the carburizing material. A broad dark band running all around the specimen will be noted. Attention is called to the fact that the dark band on this specimen is broader and that it extends clear to the edges of the specimen.

Figs. 3, 4 and 5 are photomicrographs of these specimens. Fig. 3 shows the edge of the specimen heated in sand. It will be noted that




free ferrite or carbonless iron predominates. Fig. 4 is taken in the dark band of the same specimen, which appears to be pearlite. Fig. 5 shows the edge of the specimen heated in the carburizing material. It will be noted that pearlite (the iron-ironcarbide alloy) predominates.

After making the micro examination the balance of the specimens were heated to 1500 degrees Fahr. and quenched in cold water, and tested under the scleroscope. The following results were obtained:

| | Hardness Number |
|---|---|
| Heated in sand..... | 35 |
| Heated in carburizing material. | 75 |

It appears to the writer that this is conclusive evidence that the carburizing material has had some action. It may be true that the action is not that of carburizing, but of different degrees of oxidation. That is, the carbon monoxide produced by the carburizing material may act as an oxidizing agent to the silicon but not to the carbon. If this were true we would expect that the silicon in the outer zone

would be oxidized and that it would cease to prevent the formation of combined carbon. Consequently it would be possible to have pearlite in the outer zone but not in the center of the specimen.

On the other hand the specimen heated in sand was subjected to a more vigorous oxidizing action, consequently, both the carbon and the silcon were oxidized in the outer zone and only the silicon in the next zone. If this theory is correct it would explain ferrite and pearlite bands around the specimen heated in sand and the pearlite band around the one heated in the carburizing material.

# NOTES FROM THE U. S. BUREAU OF STANDARD*

## Study of Quenching Media for Heat Treating

IN CONNECTION with the investigation which the Bureau is conducting on the effect of various quenching media used for the heat treatment of steel, 90 cooling curves were taken during the past month on steels varying from 0.25 to 1.25 per cent carbon with the object of studying the critical cooling rate to effect hardening. The apparatus used records the presence or absence of the normal, the lowered, and the "split" transformations on cooling at the cooling rates obtained in quenching. Even at cooling rates in the neighborhood of 335 degrees Cent. or 600 degrees Fahr. per second, the apparatus records these transformations. Some of the results are at first sight, anomalous, and hardly in accord with the usual conception of what occurs during quenching. They appear, however, to be generally consistent with the super-cooling or "delayed crystallization" explanation given by Hallimond from the standpoint of physical chemistry. It is believed that this work will point out that the hardness of steel by quenching follows the laws of physical chemistry and is not such a mysterious matter as is usually supposed. Many hardness tests and microscopic examinations will be required to round out this work.

## High Temperature Tensile Tests of Metals

Some of the work which the Bureau has been conducting on the tensile tests of metals at high temperatures has been previously described. Recently a series of short time tensile tests from room temperature to 1200 degrees Cent. (2200 degrees Fahr.), has been carried out on two nickel-chromium-iron alloys of commercial composition in the cast and annealed conditions. Progress is being made in developing the method and designing and constructing the apparatus for sustained load testing at high temperatures. It is of interest to note that the construction of adapters and supporters for use in the various pieces of high temperature testing apparatus is quite a serious problem since these members are subjected to very severe service and their maintenance is no small problem. It has been necessary to make up special alloys for these parts. Cast nickel-chromium-iron-tungsten alloys give fairly good service when the strength at high temperatures is the property needed. When the parts must show toughness as well, it is necessary to use other alloys. A combination of nickel and manganese is now being tried. Other special alloys will be made up and tried out to determine their suitability for this work.

## Cause of Brittleness of Tin

A sample of tin was recently analyzed by the Bureau to determine the reason for its brittleness. This defect was found to be caused by about

*Information obtained from Technical News Bulletin No. 85, published by the Department of Commerce, Bureau of Standards, Washington.

one-half of one per cent of aluminum. Aluminum is unusual in tin, and the Bureau had no tested method for its separation and determination. Several methods were tried and it was found that Gooch's method could be used with slight modifications. The method has also been further modified, so that now it is applicable to brasses and bronzes. Good results have been obtained except with those of high lead content, and it is believed that with some additional changes in the method successful analyses of a wide variety of materials can be conducted in a comparatively short time.

### Compression Test of Iron Ore

In connection with its study of mine column failures the Bureau of Mines has requested the Bureau of Standards to carry out an investigation to determine the compressive strength of iron ore under vibration. Apparatus has been designed for these tests and it is hoped that as a result of the work some information of value may be obtained.

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## NOTES FROM THE U. S. BUREAU OF MINES*

### Preparations of Super-Refractories

ON INVESTIGATION having for its purpose the production, by electric furnace methods, of materials of higher refractoriness than those commonly used in commercial practice is being conducted by the Department of the Interior at the Seattle, Wash., experiment station of the Bureau of Mines. Such refractories have been called super-refractories. The first material to be investigated is sillimanite. Two methods of preparing the material are being studied, namely, (1) From a mixture of clay and aluminum oxide in the form of bauxite, diaspore, or alunite residue; (2) From clay alone by removing the requisite amount of silica and the iron by melting with carbon in the electric furnace. The material thus produced in the electric furnace is then subject to the methods of testing refractory materials and is fashioned into brick and other shapes and given both refractory and commercial test.

Encouraging progress has been made in this investigation. It is expected that the work on sillimanite will be completed during the present fiscal year and that another material will be taken up.

### Cyanite

Cyanite, a mineral identical in chemical composition with andalusite and sillimanite, but differing in crystal form, has not yet been exploited to the same extent as andalusite, but has many interesting possibilities, states the Department of the Interior, in serial 2587, recently issued by the Bureau of Mines. Deposits believed to be of commercial importance are reported at a location about 20 miles southwest of Wheatland, Wyoming, and near Charlotte Court House, Virginia. The latter deposit is being developed at present. The commercial possibilities of cyanite are not yet fully known. Like andalusite it inverts to sillimanite when heated to high temperatures, and possibly may be used to produce sillimanite for refractory purposes.

*Information obtained from April and May, 1924, Press Memorandums of the Department of the Interior, Bureau of Mines, Washington.

## Vanadium

Vanadium is one of the most useful of the rare metals, states J. E. Conley in Bulletin 212, recently published by the Department of the Interior, through the Bureau of Mines. The chief deposits of vanadium by far the most important in the world, are at Minasragra, Peru, 20 miles from Cerro de Pasco. The main ore body is a lens-shaped mass about 30 feet wide by 300 to 400 feet long; it contains several minerals, that constituting the larger part of the deposit being called "quisqueite." This mineral is a black carbonaceous substance containing sulphur, but no vanadium. The vanadium lies mostly at the southern end of the ore body, and to a depth of 20 feet is present as red calcium vanadate; this vanadate is brighter than that in Colorado and Utah, and it may carry as much as 50 per cent vanadium oxide. It occurs in small pockets and fills the cracks and fissures in the fine shale. Below is the mother lode, which carries as high as 10 per cent vanadium oxide, and nearly as much sulphur. On the east and south sides of the mother lode is a hard blue-black vanadium shale carrying as much as 13 per cent vanadium oxide and 4 to 5 per cent sulphur. The main mineral is patronite, which is greenish black and contains 19 to 24.8 per cent vanadium oxide.

In the United States the largest deposits are in San Miguel county, southwestern Colorado. The mineral at that place is roscoelite, which is a vanadium mica. The vanadium mineral, which is light to dull green and fine-grained, is found in a sandstone that occasionally carries splotches of carnotite, but the amount of uranium present is extremely small. The average ore mined has a content of from 1 to 2 per cent vanadium oxide.

Vanadium ore has also been discovered in Huerfano county, Colo., near the Sangre de Cristo range. The ore is heavy, black and banded, and contains small quantities of uranium oxide. It shows 2 to 7 per cent vanadium oxide.

In Eagle county, 7 miles southeast of the town of Eagle, a silver ore has been found carrying vanadium, but it is more or less local in character. Zinc descloizite has been found in limited quantities in Nevada, and cuprodescloizite exists in reasonable quantities in the Shattuck mine, at Bisbee, Ariz. Vanadanite, or lead vanadate, occurs in several places in the West, particularly in Arizona, New Mexico, Nevada and California. This mineral is almost invariably found as a low-grade ore carrying from 0.1 to 0.6 per cent vanadium oxide, seldom in high-grade pockets.

The principal use of carnotite during the last few years has been in the production of radium. Ordinary carnotite ores carry from 3 to 6 per cent vanadium oxide, and the vanadium in the ore is recovered during extraction of radium. Some ores high in vanadium but low in uranium and radium have been treated primarily for vanadium, but this procedure is not usual. From 200,000 to 300,000 pounds of

vanadic oxide is probably produced annually as a by-product in the extraction of radium.

Vanadium is used chiefly in steel for purposes requiring great toughness and torsional strength, such as automobile parts, gears, piston rods, tubes, boiler plates, transmission shafts, bolts, gun barrels, gun shields, and forgings that have to withstand heavy wear and tear. The vanadium content of such steels ranges from 0.1 to 0.4 per cent. Vanadium is also used occasionally in certain tungsten alloys for making high-speed tool steel, as the introduction of a small proportion of vanadium reduces the proportion of tungsten required to give the alloys the desired hardness and toughness.

Vanadium differs from tungsten in having a beneficial effect not only on tool steel, but also on structural steel. It has been shown that vanadium does not form a double carbide with iron, but gradually takes the carbon from the carbide of iron until iron carbide cannot exist, if 5 per cent of vanadium is present, and only a vanadium carbide containing 15 per cent of carbon, is present; this constituent is constant, at least in tool steels containing 5 to 14 per cent of vanadium.

Chrome-vanadium steels and chrome-vanadium-molybdenum steels are the latest development in structural alloy steels that have gained an extensive market. Almost all these steels are made in the open-hearth furnace, chromium and vanadium alloys being added shortly before casting. In their physical properties these steels are much like chrome-nickel steels, but they have a greater constriction of area for a given limit. Most of the chromium-vanadium steels made go into automobiles. Some manufacturers prefer them because of their greater freedom from the surface imperfections, notably seams, which the steel that contain nickel are likely to have. Some chromium-vanadium steel, which is not face-hardened but has high resistance imparted by heat treatment, is used in armor plate of medium thickness.

Vanadium is used to some extent in making bronzes, in medicines and in dyeing. Methods of analysis that are applicable to vanadium ores and their products, and which have been tested by the Bureau of Mines, are described in Bulletin 212, "Analytical Methods for Certain Metals," copies of which may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., at a price of 40 cents.

# The Question Box

**A Column Devoted to the Asking, Answering and Discussing of Practical Questions in Heat Treatment — Members Submitting Answers and Discussions Are Requested to Refer to Serial Numbers of Questions**

## NEW QUESTIONS

*QUESTION NO.* 129. *Does full annealing chromium and tungsten magnet steel, before hardening, affect the magnetic properties? If so, what is the cause?*

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*QUESTION NO.* 130. *Is there any advantage in using notched-bar impact tests in the inspection of annealed tool steel bar stock? What does such a test show?*

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## ANSWERS TO OLD QUESTIONS

*QUESTION NO.* 93. *What are the more common methods of quenching ordinary taps. Are they quenched all over and the shanks drawn, or are they quenched only on the threaded portions; or are both the threaded portions and the tangs quenched, leaving the center portion of the shanks soft?*

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*QUESTION NO.* 98. *What heat treatment will give a pure martensite structure throughout the hardened area of a piece of steel* 6 *x* 2 *x* 3½ *inches?*

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*QUESTION NO.* 106. *What are the effects of the products of combustion upon both carbon and high-speed steel, when heat treated in open furnaces heated with city gas, coal, coke, fuel oil, etc?*

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*QUESTION NO.* 110. *Do notched bar impact specimens give more uniformly constant results than un-notched specimens?*

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*QUESTION NO.* 119. *What is the advantage of sulphuric acid as a quenching medium?*

ANSWER. An answer to this question is incorporated in the answer to question No. 123.

*QUESTION NO. 120. How does the carbon content affect the secondary hardness of high speed steels?*

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*QUESTION NO. 122. What are the mechanical properties of stainless steel and stainless iron?*

ANSWER, By Edwin T. Jackman, Firth-Sterling Steel Co., Chicago.

The following tabulation shows the comparative physical properties of various types of stainless steel and stainless iron on materials manufactured by the Firth-Sterling Steel Company.

| Type | Yield Point lbs. per sq. in. | Tensile Strength lbs. per sq. in. | Elong. per cent | Red Area per cent | Brinnel No. | S.I. No. |
|---|---|---|---|---|---|---|
| Steel annealed ..... | 65,000 | 99,950 | 27 | 58.7 | 175 | 29 |
| Oil quenched at 1825 degrees Fahr. drawn to 950 degrees Fahr. ..... | 210,000 | 250,000 | 4 | 10 | 475 | 70 |
| Heat treated ..... | 150,000 | 175,000 | 12 | 42 | 300 | 48 |
| Iron as rolled ..... | 52,000 | 91,000 | 22 | 39.7 | 183 | 34 |
| Iron air cooled at 1900 degrees Fahr. ..... | 111,000 | 145,250 | 6.5 | 8.9 | 280 | 45 |

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*QUESTION NO. 123. What are the advantages of using a hot soapy-water quenching medium?*

ANSWER. In answer to this question, extracts from the work of T. D. Lynch and N. B. Pilling as presented before the Chicago 1919 meeting of the American Institute of Mining and Metallurgical Engineers, entitled, "Cooling Properties of Technical Quenching Liquids," are herein given.

"The method used in obtaining these measurements involved the accurate recording of the fleeting temperatures within a metal cylinder heated to a fixed initial temperature and rapidly transferred to a bath of the quenching liquid. This required: (1) A temperature-indicating device of minimum thermal capacity, capable of faithful response to rapid temperature changes; (2) A temperature-recording instrument sufficiently sensitive to respond to the fluctuations of (1); (3) A quick and uniform means of transferring the metal cylinder from furnace to bath." The metal cylinder was so mounted on the end of the thermo-couple that it could be readily immersed in the quenching medium. The thermo-

couple was connected with an automatic autographic temperature-recording device so that autographic records could be made of the changes in temperature of the cylinder. Among the quenching mediums studied in this investigation, were those of water, brine, oil, sulphuric acid and hot soapy water solutions. In the case of the soap solutions, 2 per cent of ivory soap was dissolved in hot water. It was found that stronger concentrations than this solidified when cold. At 20 degrees Cent. (68 degrees Fahr.) this solution was a thick jelly, but was fluid at 30 degrees Cent. (86 degrees Fahr.). The analysis of the solution was: total solids, 1.85 per cent; true soap, 1.47 per cent.

In brief, the following is a description of the phases in obtaining these autographic cooling curves. Fig. 1 is the curve of a standard cylinder quenched in water at 58 degrees Cent. (136

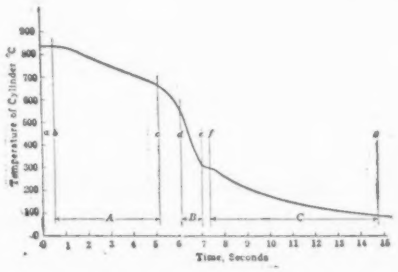


Fig. 1—Cooling Curve of Standard Cylinder When Quenched in Tap Water at 136 degrees Fahr., from an Initial Temperature of 1525 degrees Fahr.

degrees Fahr.) from an initial temperature of 830 degrees Cent. (1525 degrees Fahr.). "The record starts at 'a', with the cylinder leaving the furnace; at 'b' it enters the quenching bath and at this instant the water in immediate contact with the surface of the cylinder is quickly raised to the boiling point and vaporized, forming an envelope of steam around the cylinder. The cooler layers of water strive to condense this steam, while heat flowing from the hot cylinder tends to superheat it. The survival of this steam jacket depends on the relative rates at which heat is delivered through the jacket to the boundary surface between steam and water, and is removed from it by the adjacent cooler layers of water. In this case the former is the greater and the vapor jacket, with its relatively poor thermal conductivity, persists. The branch of the curve between 'b' and 'c' represents the sojourn of the cylinder

in this atmosphere of steam. At 'c' the two rates become equal, reverse in magnitude, and at 'd' the vapor jacket disappears. There is now liquid contact between the heated surface and the water, and as the temperature of the metal surface is far above the boiling point of water, vigorous boiling ensues, each minute bubble of steam formed being whirled away by the forceful local convention currents and immediately condensed. From 'd', where a steady loss of heat by this means is attained to 'e' the liquid shows a great capacity for absorbing heat quickly and the temperature fall is very rapid. As a result of this vigorous campaign of vaporization and condensation, a concentric layer of water of appreciable thickness at the boiling temperature accumulates and the quick cooling terminates at 'e'. Further absorption of heat by this concentric layer tends toward the re-establishment of the vapor jacket and a virtual halt in the cooling results. About 0.3 second is now consumed in cooling this layer before the cooling of the cylinder is resumed at 'f', and from 'f' to 'g' the heat absorption, relatively slow, is by thermal conduction into water below the boiling point.

"To summarize, the rather complicated mechanism of heat transfer during quenching, may be divided into three stages, arranged in a descending temperature sequence:

| Stage | Character | Designation |
|---|---|---|
| Cooling in vapor | Slow | A |
| Cooling by active vaporization | Rapid | B |
| Cooling in liquid | Slow | C |

"For convenience, in reference we may call these three modes of cooling A, B and C, respectively. Cooling in accordance with this series of stages has been found true in all of the liquids examined."

Cooling and quenching-power curves of the soap solutions are shown in Figs. 2 and 3. The A stage is prominently present at temperatures as low as 20 degrees Cent. (68 degrees Fahr.).

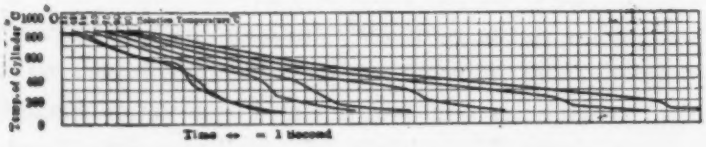

Fig. 2—Cooling Curves of Standard Cylinder Quenched in Soap Solution.

when the solution sets into a thick jelly. This gives a very low initial quenching value continuing to cylinder temperatures of 200-300 degrees Cent. (390 to 570 degrees Fahr.) lower than with water under corresponding conditions.

Fig. 4 shows quenching-power curve of technical quenching liquids based on cooling velocity at 700 degrees Cent. (1292 de-

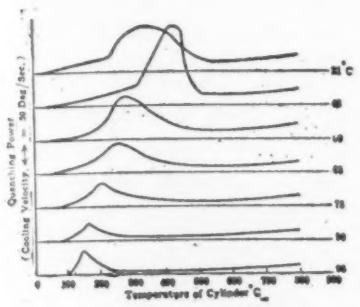

Fig. 3—Quenching Power of Soap Solution.

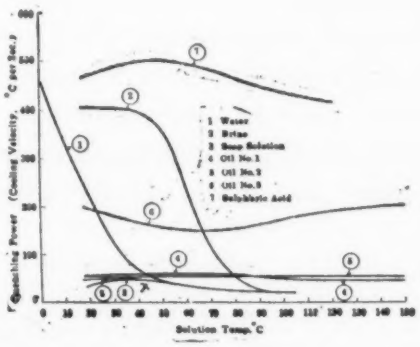

Fig. 4—Quenching Power of Technical Quenching Liquids Based on Cooling Velocity at 700 degrees Cent. (1292 degrees Fahr.).

grees Fahr.). It will be observed that soapy solution (curve No. 3) has the lowest and the concentrated sulphuric acid (curve 7) has the highest quenching value of any of the mediums tested in this investigation.

## Concentrated Sulphuric Acid

"As shown in Fig 5, cooling begins at once in the B stage with a very high quenching power, somewhat greater than that

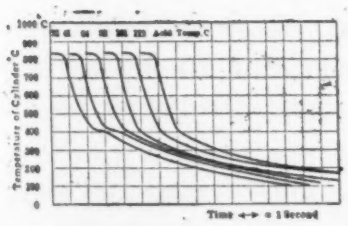

Fig. 5—Cooling Curves of Standard Cylinder Quenched in Concentrated Sulphuric Acid.

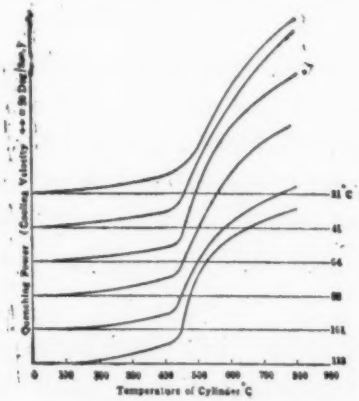

Fig. 6—Quenching Power of Sulphuric Acid.

of brine, and continues to about 400 degrees Cent. (750 degrees

Fahr.), where the C-stage cooling, with its characteristically low rate of heat absorption, begins. The quenching-power curves for sulphuric acid are shown in Fig. 6. The major mechanism of quenching is not affected by a rise in acid temperature to 118 degrees Cent. (245 degrees Fahr.), and at no time is the A-stage cooling observable. The high B-stage quenching power has a tendency to decrease at the higher acid temperatures."

"Fig. 7 diagrammatically shows the quenching characteristics of oil No. 1—soap solution and sulphuric acid quenching mediums as observed in this investigation."

"At 700 and 600 degrees Cent. (1292 and 1112 degrees Fahr.), the soap solution lies wholly within the A field, yielding at these

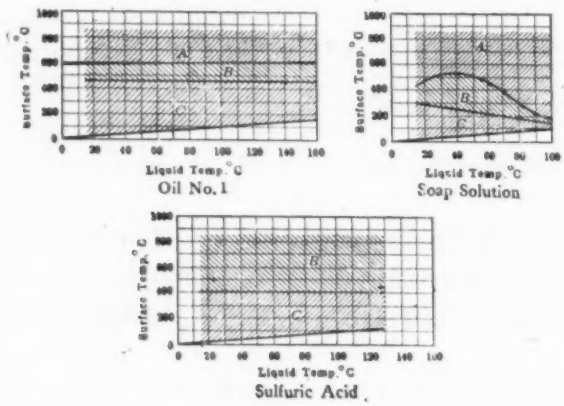


Fig. 7—Quenching Characteristics of Oil No. 1 Soapy Water and Concentrated Sulphuric Acid. A—Cooling in Vapor; B—Cooling by Active Vaporization; C—Cooling in Liquid.

temperatures a slow quenching medium, safe in this respect throughout the whole scale of solution temperatures. Notice the narrow and distorted B field, which would be expected to minimize the stresses caused by rapid cooling through a considerable temperature interval. The complete stability of all the oils and sulphuric acid is indicated by the horizontal orientation of all their fields.

"Stability of quenching power with respect to change in liquid temperature is a valuable and, perhaps, necessary property for a good quenching liquid, and its realization is found when cooling is restricted to any one of the three stages (A, B, or C). The line of separation between the A and B fields was taken as

that temperature at which an increase in the rate of cooling was first apparent; the actual transition from A to B stages takes a matter of 100 degrees Cent. (212 degrees Fahr.) to accomplish, and hence too quantitative an interpretation of the diagram (Fig. 7) is to be avoided. In a diagram of this sort, stability of quenching power is indicated when the horizontal line representing the surface temperature with reference to which the quenching power is taken, remains wholly within one field. Conversely, in passing from one field into another, changes in quenching power of large magitude may be expected."

"If a comparative value of 1.0 is taken for the quenching power at 700 degrees Cent. (1292 degrees Fahr.) in the fully developed A stage of an aqueous solution, i. e., 100 degrees Cent. (212 degrees Fahr.) solution temperature, then the relative values of the different liquids at 38 degrees Cent. (68 degrees Fahr.) is as follows:

COMPARATIVE QUENCHING POWER

| | |
|---|---|
| Water | 11 |
| Brine | 20 |
| Soap Solution | 1.3 |
| Oil No. 1 | 2.5 |
| Oil No. 2 | 2.0 |
| Oil No. 3 | 10 |
| Sulphuric acid | 24 |

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*QUESTION NO.* 124. *Why is nickel never used in tool steels? It is understood that nickel combines with ferrite to form a solid solution in steel and that solid solutions are harder than pure metals, hence it ought to make steel harder. Also nickel is said to lower the critical temperature, and if so should make steels easier to quench and harden and they would not require as high a temperature for heating. Why is it that an element which apparently is so valuable is not used more as an alloying element in tool steels?*

ANSWER. By Dr. P. D. Merica, director of research, International Nickel Co., New York City.

There is a tradition that nickel does not improve tool steel, of which the writer has been unable to ascertain the precise origin except that its presence is claimed to soften the cutting edge when in operation. As a consequence of this tradition, little experimental

or development work on the use of nickel in tool steels has been done in the last 10 or 15 years, and very little accurate information on the subject is available at the present time.

Tools may be divided into two classes, the so-called high-speed tools, which operate at a very high temperature, and other tools, such as dies, punches, chisels, saws, etc., which operate at ordinary temperatures, or not far therefrom. In the latter class there is a substantial field of usefulness for nickel-bearing steels, particularly where the service demands not only hardness but toughness as well. In fact, there are on the market at the present time nickel tool steel compositions for chisels, band saws, rock drills, punches and dies; and these compositions have given most excellent service, from all accounts.

In the case of the former class, however, a reason may perhaps be seen why nickel may not be satisfactory as a principal alloying element in steel, and that is, that it lowers the temperature of transformation, (as is pointed out in the question). For this reason, a nickel-bearing steel tends to soften at lower temperatures, and therefore, cannot be as efficient as one in which the alloying element tends to raise the transformation temperatures, particularly the temperature of precipitation and coalescence of carbide.

Even here, however, we are still somewhat in the dark, since a great many high-speed tool compositions contain small amounts of nickel, to which the writer has heard actual positive beneficial effects ascribed, although has not personally had the opportunity to confirm. It is of interest also that within the last few years there have been developed high-nickel content high-speed tool compositions—not steels—which appear to be competitors of the present standard high-speed steel compositions.

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*QUESTION NO.* 125. *What is a suitable test to apply to a carburizing box before installing it in service?*

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*QUESTION NO.* 126. *How should steel castings be specified and purchased?*

ANSWER. An editorial published in the March-April 1924

issue of the *Edgar Allen News,* Sheffield, England, presents the English point of view on this subject.

The easiest way to buy steel castings is to send our inquiries and give the order to the firm that submits the lowest price. This procedure requires little skill, intelligence, or forethought, and is thoroughly inefficient. Practiced buyers take into account the much more important factors of the production-capacity of each works, the quality of the product, and the experience of the manufacturer in the production of a particular class of casting. These things constitute what is known as "service," the something over and above the goods that the experienced and trustworthy manufacturer gives to his customers.

### What Quality Means in Steel Castings

Quality is a word of common use, so common that it is apt to be accepted without close inquiry into what it means. In general, every manufacturer puts *some* quality into his goods, but the amount of quality is so closely reflected by the price, that a sound proverb crystallizing this fact has come into existence: "What's cheap's dear."

In steel castings, quality means far more than price, delivery, or any other factor. Castings for railways, for instance, have to pass without doubt or difficulty the most stringent tests. To buy castings that could not pass these would be to risk disaster and endanger the lives of men and women. The same argument applies to many other kinds of steel castings. Obviously, therefore, to enable the castings to meet all requirements, the most up-to-date methods must be employed by experienced steel-foundry workers on first-class material, a combination of conditions that can only be guaranteed by a firm of long experience and high standing in this branch of manufacture.

### Castings in the Rough or Finished-machined

Long experience in the manufacture of steel castings has led to the conclusion that far more should be done by the steel-founder in supplying castings finished-machined and ready for use than is actually done at present. Sometimes imperfections in a casting only reveal themselves during machining. The delays that result when this machining takes place at the customer's own works are

irritating. The buyer invariably loses, not only on account of the delay, which may hold up a big consignment of his own products, but also because he has spent money on machining a defective casting. On the other hand, the replacement of a finished-machined casting is a more serious matter for the steel-founder than that of one supplied in the rough. In the former case the founder bears the expense of machining done on the waster. Therefore, for his own sake, he exercises the greatest possible care in the foundry. Ordering steel castings finished-machined enables constant touch to be kept between the machine shop and the foundry, and so leads to the effecting of improvements and the elimination of defects.

## How to Order Steel Castings

It is essential to observe the three following requirements when ordering steel castings:—

1. Send drawings or tracings showing finished dimensions and colored red to indicate the parts of the castings intended to be machined. Tracings should have overall dimensions marked on them, and also the thickness of the various parts so that a close estimate of weight can be worked out.
2. Indicate the number of castings required.
3. Give, if possible, the weight of each casting.

To obviate delays, full particulars of requirements should be stated on all inquiries and orders, and quality and kind of material should be specified, whether cast steel, chrome steel, manganese steel, etc. If the customer is in doubt, he should give details of the duty the casting will have to perform, leaving the question of appropriate material to the maker. It should always be stated whether rough or finished-machined castings are required. This is specially important in sending out inquiries, because time is often wasted in taking out two costs, one for the finished-machined castings, and one for castings in the rough, so that both prices can be submitted to the buyer. It should also be stated whether the patterns are already in existence, or whether the intention is that the steel-founder should supply his own.

In the case of gearing and large circular castings, when customers supply their own patterns, it should be made clear on

the order or inquiry whether molding-tackle or full patterns are to be sent, since the molding costs vary considerably for each type.

The quantities required must, for price-inquiry purposes, be stated, to enable the steel-founder to decide the method of manufacture, because in the case of large quantities special arrangements can often be made to cheapen production.

When the customer decides to make his own patterns, he should consult the steel-founder as to the best way of making them. Labor-saving methods in large steel-foundries, have been so perfected that a pattern made in an unsuitable manner may easily increase the cost of the castings by a considerable amount. Patterns not made by men accustomed to foundry work are useless for molding purposes. The contraction allowance may be insufficient, or an unnecessary intricacy may mean exceptional difficulty in molding.

Never send patterns too old for use.

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*QUESTION NO.* 127. *How should tool steel be specified and purchased?*

ANSWER. An editorial published in the March-April 1924 issue of the *Edgar Allen News*, Sheffield, England, presents the English point of view on this subject.

So many factors enter into the question of what is an economical steel for the particular job or class of work, that it is next to impossible for a buyer to decide by merely glancing through the pages of a catalog, what steel it will pay him best to use. For instance, all classes of tool-steel from the high-speed steel down to the high-carbon tool-steel, can in their several ways be economical in certain instances for such tools as twist-drills. But before a buyer can decide when a twist-drill of Red Label tool-steel, for example, is more economical to use than one made of Extra Special, he must take into account the quantity of work to be turned out in a given time, the character of the material being drilled, the amount of profit on the work; or in the case of a twist-drill manufacturer, the particular market for which he in-

tends to cater, the prices with which he will have to compete, and so on.

Whether steel is selected for quality or price makes no difference to one ruling principle. Cheap or costly, it must be dependable. The same label must always guarantee the same grade, composition, and character. It follows that a known brand—what is sometimes known as the hall-mark of steel—is indispensable. Steel should no more be bought without a hall-mark than are gold rings or silver spoons. The price paid for a recognized standard steel buys something more than a certain weight of metal and alloys. It buys service, skill, experience, watchfulness, and the guarantee of self-interest on the part of the manufacturer, who could not afford to put his mark on anything not up to test.

## When it Pays to Buy Cheaply

With this reservation that, cheap or costly, the steel should have a reputation behind it, there are uses for which it is profitable to buy the cheaper grades of tool-steel.

When the steel is to be used in a workshop where conditions do not require the employment of skilled workers, there is no advantage in buying the best grades of steel. Such steels require careful treatment in order to obtain the best results. Lacking this, they give no better service than the grades easier to treat. Such shops include, for example, small engineering works abroad using native labor; gold and other mines; and similar places where neither physical conditions nor the type of workman available allow of accurate heat-treatment and other careful work.

## When Costly Steels are Economical

On the other hand, it is often an economy to use, disregarding cost, the steel that is the best possible for a given purpose. Circumstances dictating this course may be permanent or temporary. For example, in making tools of an elaborate type, where the main element in the cost is labor, the most important consideration is that the tools shall be as good, and shall remain efficient for as long a time as possible. However costly the steel, it is in such cases a minor expense compared with labor. The best steel gives the most economical results.

Again, when production must be maintained at high pressure,

or increased either temporarily or permanently, output is a prime consideration. It is better to use more expensive tools than to have work delayed. The expense of using the best known steel for the purpose is trifling compared with the increased output.

But whatever the price of tool-steel, its efficient use demands correct treatment of each variety according to purpose.

### The Purchase of Tool Steel

Before buying steel for tools or any other purpose, the user will do well to consider the following points, which may conveniently be arranged in the form of questions:—

1. For what purpose is the steel to be used?
2. Is it desirable to use a high, medium or cheap grade?
3. Quantity required? (How many bars, feet, hundredweights or lbs.?)
4. What shape is required? (Round, square, flat, bevel, octagon, etc.)
5. What size or sizes? (Many users order too small a size. The result is that tools not only run great danger of breaking, through the strain being greater than they can bear, but are also liable to fail because the section is too small to absorb the heat generated by rapid cutting.)
6. Is the steel required annealed?
7. If ordering by length state whether approximate or exact lengths are required.

Note.—High-speed steel is always sent annealed unless otherwise specified, and no extra is charged for this work. Where tools are forged from the steel, the heat applied in the forge makes annealing unnecessary. Tool-steel that is to be machined requires annealing.

When calculating the weight of high-speed steel remember that 10 per cent should be added for air-hardening and 12½ per cent for special to the figures given in general calculating tables. The greater density of this steel makes it a heavier bar than ordinary tool-steel.

High-speed steels are delivered in bars about 8 to 10 feet long; plain carbon steels in bars 10 to 12 feet long; miners' drill-steel in bars 12 to 14 feet long, or longer if required; spring steel in bars 12 to 14 feet long, or longer if required.

### How the Buyer Can Make His Tool Steel Cheaper

Through overlooking the fact that there are certain extra charges in the case of tool-steels, buyers sometimes make their tool-steel bill heavier than need be. The reason for extra charges is plain. Small sizes, being special, are not often ordered. Special rolls have usually to be put into the mill for them, unless by good fortune there happens to be some of that particular size in stock. This means, of course, that they cost more to roll than if they had been put through, as normal sizes are, with a large quantity of steel of the same size, making a change of rolls unnecessary. Also the smaller the size, the more bars there are to roll in each hundredweight, with a consequent increase in cost of production.

The large sizes, from 3 to 8 inches, are more costly to forge. Bevels also need special rolling and forging and as they are seldom ordered in large quantities, the cost of these processes is considerably increased.

Cutting steel exact lengths involves a certain amount of waste, to cover which an extra charge is charged. It would often be far more economical not to order steel in this way, but to allow the maker to supply in lengths as near as possible to those given.

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*QUESTION NO.* 128. *What heat treatment, if any, could be given to a steel casting of the following composition which would produce the physical properties as given below?*

| | Per Cent |
|---|---|
| Carbon | 0.65 |
| Manganese | 1.37 |
| Silicon | 0.37 |
| Phosphorus | 0.024 |
| Sulphur | 0.033 |
| Tensile Strength | over 70,000 lbs. per sq. in. |
| Yield Point | over 32,000 lbs. per sq. in. |
| Elongation in 2 in. | over 12 per cent |
| Reduction of area | over 18 per cent |

# Abstracts of Technical Articles

## Brief Reviews of Publications of Interest to Metallurgists and Steel Treaters

STAINLESS STEEL, WITH PARTICULAR REFERENCE TO THE MILDER VARIETIES (STAINLESS IRON). By J. H. G. Monypenny in *Transactions* of the American Institute of Mining and Metallurgical Engineers, No. 1277-S, (1923).

This paper contains a description of the structure and general properties of steel containing 11 to 14 per cent of chromium after different forms of heat treatment and the effect on such material of variations in the carbon content. A discussion is given of the effect of variations in composition and heat treatment on the resistance to corrosion of such high chromium steel. The special properties produced in such steel when the carbon content is reduced to 0.10 per cent or thereabouts are covered in detail as well as the mechanical and noncorrosive properties of such material in relation to engineering uses.

DEFINITIONS OF STEEL AND CAST IRON. By Kotaro Honda in *Bulletin* of the Institute of Physical and Chemical Research (Japan), No. 2, page 405, 1923.

The author has given the definitions of steel and cast iron from their carbon content. The maximum amount of carbon contained in iron as a solid solution at room temperature is 0.035 per cent and that of carbon which is dissolved in iron at high temperatures is 1.7 per cent; the figure has a distinct meaning with reference to the equilibrium diagram of iron carbon. Steel is, therefore, defined as an alloy of iron and carbon, which contains 0.035-1.7 per cent of carbon. From its structure, cast iron is defined as an alloy of iron and carbon, which contains above 1.7 per cent of carbon.

TITANIUM IN GRAY CAST IRON. By E. Piwowarsky in *Stahl und Eisen,* No. 43, page 1491, 1923.

This article states that titanium acts much in the same manner as silicon in the graphite formation in cast iron, though with more marked activity. By addition of titanium for graphitizing, the bending qualities of the cast iron are increased to 50 per cent or even greater amounts and the graphite at the same time becomes finer-grained. The nonmetallic compounds of titanium as nitrides, carbides and cyanonitrides are readily distinguishable under the microscope. With increased titanium content the acid solubility of the cast iron is greatly lessened.

WHAT IS THE CAUSE OF WATER-LINE CORROSION? By K. M. Watson in *Chemical and Metallurgical Engineering,* No. 29, page 706, 1923.

The author states that the solution of a metal formed at the surface of a liquid in which it is immersed flows downward along the surface of the metal. The lower part of the metal is protected from corrosion because that part of the solution which bathes it contains a higher concentration of the metal.

USE OF ALUMINUM TO PREVENT STEEL CORROSION. By A. V. Farr in *Chemical and Metallurgical Engineering,* No. 29, page 1188, 1923.

The process, known as calorizing, and consisting of alloying the surface of steel with aluminum, protects the steel against corrosion.

BRONZE-STEEL WELDS. By G. F. Comstock in *Iron Age,* No. 112, page 1381, 1923.

This paper states that bronze welding rods containing phosphorus cause the formation of iron phosphide in the neighborhood of the weld, while those free from phosphorus show a sharp line of demarcation with bronze-filled cracks running into the steel.

PROPERTIES OF STEEL CONTAINING TELLURIUM. By G. B. Waterhouse and I. N. Zavairne, in *Iron Age,* No. 112, page 1575, 1923.

The above article states that a careful examination of a steel containing 0.12 per cent tellurium shows the presence of a nonmetallic constituent that is probably a telluride, closely associated with manganese sulphide. When the steel is forged this telluride does not break up but elongates fully as well as, if not better than manganese sulphide. The steel is lower in ductility than normal material without tellurium.

SILICON ALUMINUM BRONZES. By Leon Guillet, in *Revue de Metallurgie,* No. 20, page 771, 1923.

The author has prepared, tested and examined micrographically sets of alloys containing 95, 93, 92 and 90 per cent copper respectively, and varying amounts of aluminum and silicon. The results show that an addition of silicon to the aluminum bronzes did not give any interesting results, there being appreciable improvement only with the alloy containing 92 per cent copper and 3 per cent silicon. There is frequently formed a special constituent which decreases the mechanical qualities of the alloy. Twenty photomicrographs are shown.

THEORY AND PRACTICE OF STEEL REFINING. By H. Styri in *Journal* of the Iron and Steel Institute (advance proof) 1923.

The author of this article has endeavored to show that all reactions between oxygen and the usual elements take place simultaneously. It is consequently quite impossible for silicon only to react with oxygen in deoxidizing. Manganese, carbon and iron will oxidize at the same time as silicon if present in sufficient quantities.

# Reviews of Recent Patents

*By*
NELSON LITTELL, Patent Attorney
110 E. 42nd St., New York City
*Member of A. S. S. T.*

**1,487,554, Process for Hardening Steel Alloys. Adolf Fry of Essen-Stadtwald, Germany, Assignor to Fried, Krupp Aktiengesellschaft, of Essen-on-the-Ruhr, Germany.**

This patent deals with hardening of steel alloys by nitrogenization, and is for a process which will not cause brittleness of the marginal layers of the nitronized steel and which will prevent peeling off of the layers. By way of explanation, the inventor defines the peritectic as

> "The homogeneous crystalline mass which at the cooling of alloys below certain temperature, inserts itself between the still existing molten mass and a type of crystal mixed with it and surrounds the latter. By 'peritectoid' is understood a structural element corresponding to the peritectic which is formed at a temperature lower than the temperature of solidification of a liquid alloy, in that at the expense of two already existing types of crystals a third type of crystal is formed which introduces itself as a separator between the other two and surrounds one of them."

The invention is based upon the discovery that steel alloys which have absorbed nitrogen, undergo a peritectoidal transformation which takes place at a temperature of about 580 degrees Cent. (1076 degrees Fahr.) and that if nitronization takes place below this transformation the concentration of the nitrogen remains below the limit at which the brittle layers are formed. The hardened layer, therefore, does not peel off. The invention is claimed as a process of hardened steel alloys which consists in subjecting the alloy to nitrogenization at a temperature below the peritectoidal transformation point.

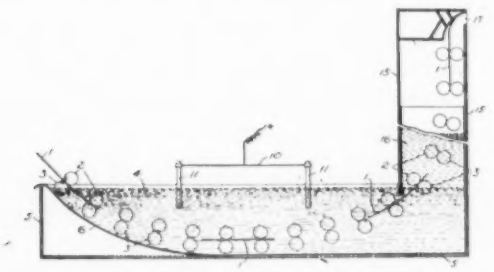
**1,487,719, Process of Malleablizing Iron. Henry T. Chandler, of Marysville, Michigan.**

This patent describes an improvement in the process of malleabliz-ing iron wherein instead of heating the metal through the critical range and holding it at that point for the required time in the same furnace, the iron is heated in one furnace and cooled in another thereby saving considerable time, permitting the heating furnace and cooling furnace to be used continuously at substantially uniform temperatures without being subjected to the extreme high and low temperature ordinarily necessary in malleablizing furnaces. The inventor has discovered that chemically the rate of heating of the article to be mal-

leablized is immaterial, and the higher the initial temperature is raised above the critical point the more rapid is the chemical equilibrium established, that the rate of cooling is immaterial except through a narrow temperature range and that the initial temperature may be considerably higher than this range. Based upon these discoveries the work is heated in the heating furnace to a high temperature for the required length of time and then removed to the cooling furnace for subsequent cooling. The loss of heat in the transferring operation is not sufficient to affect the quality of the product because of the high temperature at which the work is removed from the heating furnace.

**1,488,553. Process of Coating Sheet Steel with Aluminum.** Samuel **Peacock, of Wheeling, West Virginia, Assignor to Willis G.** Waldo, of **Washington, District of Columbia.**

This invention relates to an improved apparatus and process for coating sheet steel with aluminum. In the apparatus as shown the tank 5 contains a fused bath of alkali metal—aluminum fluoride, which is kept saturated with aluminum during the plating operation. The sheet steel plates 1 are passed through the bath between the rollers



2 and 3, the rollers 2 being connected to the negative terminal of the circuit so as to cause the aluminum to deposit on the sheet steel plates as the cathode, carbon anodes 11 dip into the bath and connected to the positive terminal of the circuit at 10. The rolling of the plates 1 between the rollers 2 and 3 insures a smooth and uniform deposit of the aluminum.

**1,489,023. Pot or Crucible. Arthur E. Bellis of Springfield, Mass., and Charles S. Collins of New York, N. Y. Assignors to the Bellis Heat Treating Company of New Haven, Conn.**

Messrs. Bellis and Collins in this invention seek to avoid the defects in the prior pots or crucibles used for containing the molten metal or salt baths for heat treatment, which crucibles often develop porosity after a few hundred hours of use, by substituting for the cast chromium alloy crucibles of the prior art, a wrought pot or crucible of material of substantially the same composition as those heretofore

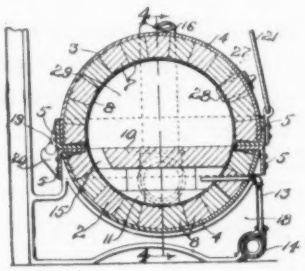
used. The wrought pot is absolutely nonporous and, therefore, effectually prevents deterioration of the pot structure in service. An alternative method of securing this desirable result according to the patent is to provide the cast metal pot with an internal lining of pressed steel, wrought iron, cast steel or the like, the lining being of nonporous construction so as to prevent leakage of the molten bath and the exterior being of a substantially nonoxidizing composition so as to resist the oxidizing action of the heating flames.

**1,489,118. Method of Treating Steel. Anthony J. Freitas, of Erie, Penn.**

This invention relates to an improved material and method of treating molten steel for the purpose of scavenging and purifying the same. The inventor uses a compound, preferably made up of 40 parts of potassium prussiate (yellow), two parts fuller's earth and six parts charcoal which compound is introduced into the molten steel in the furnace, crucible or ladle preferably in the ladle to reduce the melting losses. The addition of this material momentarily increases the temperature of the steel, apparently increasing the physical characteristics, such as tensile strength, elasticity, elongation, etc., varies the transformation point so as to produce better annealing and seems to change the fiber structure so as to reduce to a large extent cracking of the metal during quenching.

**1,489,626. Heat-Treating Furnace. Samuel Theodore Bittenbender of Brookline, and John G. Allan, of Quincy, Mass.**

This invention relates to the improved type of furnace especially for tempering and annealing metal bars. The furnace is composed of a cylindrical casing of a length several times greater than its diameter



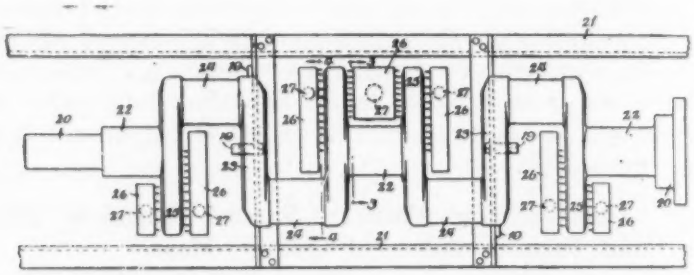
comprising a lower portion 2 and an upper portion 3 hinged together at 19 so that the upper portion can be lifted from the lower portion for the purpose of charging or removing the bars or the like from the furnace. A hearth 10 of firebrick supported along a plurality of walls 11 is provided in the lower portion 2. The gas or other fuel is introduced below this hearth from the pipes 13 leading from the manifold 14. The gas burns below the hearth and the combustion gases flow upward through the openings 15 into the upper portion of the

hearth and are discharged from the pipes 16 at the ends of the furnace. The furnace is especially recommended for economy of fuel and the ease with which the material being treated can be placed in and removed from the furnace.

**1,489,682. Method of and Apparatus for Heat Treating Steel Articles. Harold F. Wood, of Chicago, Ill., assignor to Wyman-Gordon Co., of Worcester, Mass.**

This patent describes a method and apparatus for selectively hardening the pins, bearings, cheeks and counterweights of crank shafts.

It is necessary in a counterweighted crank shaft to provide sufficiently hardened bearing surfaces and cheeks of sufficient strength to resist the stresses to which they are subjected, however, the counterweights need have only the necessary strength to resist the centrifugal force to which they are subjected and it is preferable to have them relatively soft in order to decrease the cost of machining. In



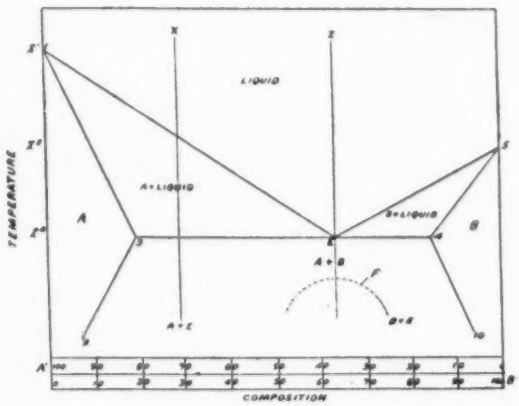
the method as described the forged crank shaft is placed upon suitable supporting and positioning arms 19 and 21 and heated above the $Ac_3$ point sufficiently so that the crank shaft proper will remain above the $Ar_3$ point until quenched. The temperature is preferably about 1525 degrees Fahr. The counterweight portions are then cooled to a temperature below the $Ar_1$ point by subjecting them to an air blast from the nozzles 26 while the remainder of the crank shaft remains above the $Ar_3$ temperature. When the temperature of the counterweights has been reduced below the hardening range the crank shaft is then quenched to harden the crank shaft proper, the counterweight portions remaining unhardened.

**1,491,510, Fused Eutectic Salt Bath. Arthur E. Bellis of Springfield, Mass. Assignor, By Mesne Assignments to the Bellis Heat Treating Company, of New Haven, Conn.**

This patent covers broadly the use of a fused eutectic salt bath for use mainly in the heat treatment of metals. The inventor in three constitutional diagrams represents graphically (1) a mixture of two salts which do not form chemical compounds, or conjugate liquids when in a fused state, (2) a mixture which forms conjugate liquids

and (3) a mixture of salt components which form both chemical compounds and conjugate liquids and points out in connection with each that the eutectic mixture or mixtures has the lowest melting point and hence the greatest fluidity and a relatively high volatilization point, etc.

In the diagram reproduced herewith representing a mixture of two salts, *a* and *b* in proportions as indicated on the scales A′ and B′ at the bottom of




the diagram, t′ is the freezing temperature of salt *a*, $t^5$ is the freezing point of salt *b* and te is the freezing point of the eutectic.

1, E, 5 is the liquidus line, 1, 3, 4, 5 is the solidus line and 9, 3, 4, 10 are the solid solution lines. It will be readily apparent from the diagram that the eutectic mixture represented by the line Z has, as is characteristic of eutectic mixtures, the lowest melting temperature of any mixture of the components, is entirely liquid above the temperature te, and entirely solid below the eutectic temperature. There is, therefore, only one phase (liquid or solid) in an eutectic salt bath at any temperature except just at the temperature te and above the temperature te the bath consists of a single liquid the composition of which remains invariable under all temperature changes below the point of volatilization.

In the use of an eutectic bath of certain salt mixtures for the treatment for example of 0.40 per cent carbon steel, the bath is heated slightly above the critical temperature of the steel (about 1500 degrees Fahr.) When the steel is first immersed in the bath, some of the salt solution will solidify upon the metal, but as the metal heats up the coating will be remelted and when the steel throughout its structure reaches the temperature of the bath it will assume a color approaching that of the bath and become only slightly visible, thereby affording a visible indication that the metal has reached its critical temperature and may now be removed from the bath and quenched. Since the eutectic mixture is most fluid there will be a rapid circulation of heat through all portions of the mixture, and the film of salt

on the metal surface when it is withdrawn from the bath will be relatively thin.

Two examples of an eutectic salt bath are given, 39 per cent of sodium chloride with 61 per cent of sodium carbonate and 71 per cent of calcium chloride with 29 per cent of sodium chloride. The claims of the patent are, however, not limited to any specific mixture but purport to cover any fused eutectic salt bath for the heat treatment of metals.

**1,491,929. Method of Making Steel. George M. Smith and Alvin A. Claassen of Chicago, Ill.**

This patent relates to a method of utilizing low grade scrap iron in the manufacture of steel and especially to the use of scrap iron having a relatively large surface area as compared to its weight and which may be heavily coated with rust.

The cheap rust coated scrap is put up into the usual bundles and has incorporated therewith an amount of aluminum sufficient to combine with the iron oxide to carry out a thermit reaction when heated in the furnace. These bundles of scrap and aluminum are charged into the furnace and when the heated furnace sets off the thermit reaction, the inner portion of the bundle is heated to a high temperature, the iron oxide and aluminum are eliminated in the thermit reaction and pass off into the slag. The initial heat of the thermit reaction being high, the furnace temperature required to melt the bundle of scrap is consequently reduced.

The grade of steel produced by this method is equal to or superior to that produced by the use of high grade and expensive scrap and the price of the cheap grade together with the aluminum is less than the price of the high grade scrap so that the cost of producing the steel by this method is reduced.

# News of the Chapters

## SCHEDULED REGULAR MEETING NIGHTS

FOR the convenience of visiting members, those chapters having regular meeting nights are listed below. It is desired that all secretaries whose chapters are not included in the list communicate with the National office in order that the list may be as complete as possible.

Boston—Third Thursday.

Cleveland—Fourth Friday, Cleveland Engineering Society rooms, Hotel Winton; meeting at 8 p. m.

Chicago—Second Thursday.

Hartford—Tuesday nearest 10th of month.

Indianapolis—Second Monday.

New Haven—Third Friday.

New York—Third Wednesday, assembly room, Merchants Association of New York, ninth floor, Woolworth building.

Philadelphia—Last Friday, Engineers' club.

Tri City—Third Thursday.

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## BOSTON CHAPTER

ON MAY 16, 1924, the Boston and Worcester chapters of the American Society for Steel Treating held a joint meeting at Hotel Warren, Worcester, Mass. At 2 p. m. the party left to visit the plants of Wyman and Gordon company, Worcester, proceeding from there to the south works of the American Steel & Wire Co. Dinner was served at the hotel at 5:45 p. m. The speaker of the evening, Dr. Ancel St. John of the Union Carbide and Carbon Research Laboratory, Long Island City, N. Y., gave a very interesting and instructive paper entitled, "X-ray Examination of Metals." Dr. St. John's work on this subject is well known and much valuable discussion followed the presentation of this paper. A very pleasant afternoon and evening was spent by those in attendance.

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## CINCINNATI CHAPTER

The Cincinnati chapter of the American Society for Steel Treating held a meeting on May 8 at 8 p. m. at Ohio Mechanics institute. W. R. Fleming, chief chemist and metallurgist, Andrews Steel Co., Newport, Ky., presented an interesting paper entitled "Alloy Steels, Their Manufacture and Heat Treatment." A very interesting discussion was brought forth following this presentation.

W. H. Eisenman, national secretary of the society, was also present. The new officers for the ensuing year were elected at this meeting.

## DETROIT CHAPTER

The Detroit chapter of the American Society for Steel Treating held a meeting on Monday, May 19. The attending members met at 2:30 p. m. in the East Engineering building, University of Michigan, for an inspection of the university buildings and grounds. A baseball game between the University of Michigan and University of Iowa was staged at 4 p. m. Dinner was served at 6:30 p. m. at Michigan Union. J. M. Watson, chairman of the chapter, presided at the meeting, which was held at 8 p. m. in the Michigan Union. "The University Program of Extension," was the title of an address given by Prof. A. H. White, chemical engineering department. Prof. W. D. Henderson, physics department, also spoke on "Recent Developments in Science."

Brief remarks were also made by Prof. E. D. Campbell, Prof. A. E. White and W. S. Bidle, first vice-president of the Society. After the addresses, a brief business session was held which included the secretary's report and announcement of the results of the election of officers for the coming year. The new officers are as follows: chairman, W. G. Calkins; vice president, H. M. Northrup; secretary-treasurer, Robert Atkinson. Executive committee consists of C. N. Dawe, H. G. Freeland, W. G. Hildorf, F. L. Woodside and H. E. Martin.

## INDIANAPOLIS CHAPTER

The Indianapolis chapter of the American Society for Steel Treating held a meeting on April 14 at the chamber of commerce at which time E. W. Pierce, metallurgist, Maxwell Motor Corp., Newcastle, Indiana, was the speaker of the evening. The title of Mr. Pierce's paper was "Some Production Data on Molybdenum Steel." This paper was very capably presented and was well received.

The chapter held their May meeting on the 12th of the month in the Y. M. C. A. building, New York and Illinois street. G. E. Schloot, production manager, Diamond Chain Co., addressed this meeting, choosing for his subject, "Some Methods of Production." W. H. Eisenman, national secretary of the society, was present at this meeting, speaking briefly on the progress and standing of the national society. Dinner was served at 6:45 p. m. preceding the meeting. New officers for the coming year were elected.

New officers for the coming year were elected at this meeting. They are as follows: chairman, W. R. Chapin; vice chairman, C. B. Edwards; and secretary-treasurer, H. A. Maves.

## LEHIGH VALLEY CHAPTER

On April 25, the Lehigh Valley chapter of the American Society for Steel Treating held a meeting at the Easton public library, Easton, Pa. P. E. McKinney, chemist and metallurgist, U. S. Naval

Gun Factory, Washington, D. C., gave a very interesting paper entitled, "Problems of the Steel Treater as Influenced by Prenatal History of the Material." This was a most capable presentation and brought forth much valuable discussion.

The chapter held a meeting on June 2 at the Bethlehem Steel Co., Battery building. "Die Castings" was the title of a very interesting paper presented by Sam Tour, metallurgist, Doehler Die Casting Co., Brooklyn, N. Y. This was a most capable presentation and brought forth much valuable and instructive discussion.

## LOS ANGELES CHAPTER

A very excellent dinner meeting was held by the Los Angeles chapter of the American Society for Steel Treating on May 7 at the cafeteria of the Los Angeles Creamery Co. Together with the tasty food which satisfied the human element, a very interesting and educational paper was presented on the subject of "The Manufacture of Tool Steel" by Thomas S. Hutton, district sales manager of the Ludlum Steel Co. Mr. Hutton very clearly described the stages of operation in the manufacturing of this high quality special grade of steel and in conclusion, placed emphasis on the meritorious features which can only be accomplished by the proper care and handling of this steel after the customer places it in service. Discussion lasting for one hour was evidence of the interest taken in the subject. Election of new officers took place at this meeting.

## MILWAUKEE CHAPTER

The Milwaukee chapter of the American Society for Steel Treating held a meeting on Monday, May 26 at Hotel Blatz. D. W. Dunbar, Norton Company, Worcester, Mass., presented an interesting paper entitled, "Grinding Problems." This was a capable presentation and brought out many valuable points of information.

## NEW HAVEN CHAPTER

The New Haven chapter of the American Society for Steel Treating held a meeting on Friday evening, April 25, dinner being served at the Milford Arms Inn, Milford, Conn., at 7 p. m. G. C. McCormick, metallurgist, Crompton and Knowles Loom Works, Worcester, Mass., addressed the chapter, choosing for his subject "Pyrometers." The following new officers were elected for the ensuing year: Chairman, J. S. Gravely, superintendent of engineering, Winchester Repeating Arms Co., New Haven; vice chairman, A. L. Davis, director of research, Scoville Mfg. Co., Waterbury; secretary-treasurer, W. G. Aurand, R. Wallace & Sons Mfg. Co., Wallingford; and assistant secretary, E. L. Wood, metallurgist, Bellis Heat Treating Co., New Haven.

## NEW YORK CHAPTER

On Wednesday, May 21, the New York chapter of the American Society for Steel Treating held its regular monthly meeting at 8 p. m. in the assembly rooms of the Merchants' association of New York. The speaker of the evening was A. H. d'Arcambal, metallurgist Pratt & Whitney Co., Hartford, Conn. The title of his paper was "Carbon Tool Steel and High Speed Steels Used in the Manufacture of Small Tools." This paper was presented in a capable manner and was well received.

## NORTH WEST CHAPTER

On May 7, through the courtesy of H. A. Anderson, a member of the North West chapter, and the Mahr Manufacturing Co., Minneapolis, Minn., the members of the chapter were invited to visit this company's plant, located at 1300 Quincy street. Heat treating furnaces, forges, torches and blowers were in operation for the inspection of the visitors. This company has built up a large business with industrial concerns and railroads throughout the country and their processes of manufacture and performance of their equipment is very well known and it was very interesting to those who had the privilege of inspecting the plant.

## PHILADELPHIA CHAPTER

The Philadelphia chapter of the American Society for Steel Treating held a meeting on Wednesday, May 28, which began at 4:45 p. m. with plant visitation of the warehouses of Horace T. Potts & Co., Philadelphia. An informal supper was served at 6:30 p. m., the visitors being the guests of the company. The meeting of the chapter took place at 7:30 p. m., at which time informal talks were given by the following prominent executives: Chas. E. Carpenter, president, E. F. Houghton & Co., Philadelphia; W. H. Eisenman, national secretary of the society; James H. Dunham, dean, College of Liberal Arts and Sciences, Temple university, Philadelphia; F. P. Gilligan, secretary-treasurer, Henry Souther Engineering Co., Hartford, Conn.; A. A. Stevenson, vice president Baldwin Locomotive Works, and president Standard Steel Works Co., Ardmore, Pa.; and Prof. Bradley Stoughton, director department of metallurgy, Lehigh university, Bethlehem, Pa. Music was furnished by Hersch's society orchestra, Adelphia Melody Four (male quartet) and Christy piano accordion. A smoker was held in connection with this, the final meeting of the season. Needless to say, the members spent a most enjoyable afternoon and evening.

## PITTSBURGH CHAPTER

The Pittsburgh chapter of the American Society for Steel Treating held a meeting on May 6 in the Hawaiian room of the William

Penn hotel. This was termed a "shop kink" meeting and discussions were lead by A. St. Clair Ogg, W. H. Phillips, N. B. Hoffman, J. J. Jones and W. B. Crowe. This meeting was very well attended and proved a success inasmuch as many helpful points were brought forth. Dinner was served at 6:30 p. m. preceding the meeting.

## RHODE ISLAND CHAPTER

The Rhode Island chapter of the American Society for Steel Treating held a meeting on April 29 at 8 p. m. in the rooms of the Providence Engineering society. G. W. Pressell, general sales manager, E. F. Houghton & Co., Philadelphia, gave a very interesting paper entitled "Quenching Media." Mr. Pressell, in addition to his capacity as sales manager, is also the head of the research department of his company, who have carried on extensive research for many years, which work has been very helpful to steel treaters; thus his presentation was very capable and brought forth much valuable discussion.

The chapter held their May meeting on the 21st at Brown university, Engineering building, Providence, R. I. Prof. William H. Kennerson, professor of engineering, Brown university, addressed the attendance on "Testing of Steel." This presentation was very interesting and much discussion followed. A practical demonstration of the Brinnel, scleroscope, Rockwell and tension tests were also given.

## ROCKFORD CHAPTER

The Rockford chapter of the American Society for Steel Treating held a meeting on May 16 at which time O. M. Olson, sales manager of the Eclipse Fuel Engineering Co., delivered a very capable talk upon the merits of a single valve control apparatus, manufactured by the concern whom he represents. This address was most interesting and was well received. The election of officers for the ensuing year took place at this meeting.

## SCHENECTADY CHAPTER

The March meeting of the Schenectady chapter of the American Society for Steel Treating was held on the 28th of the month, at which time Dr. F. C. Langenberg presented a most capable paper entitled, "Effect of High and Low Temperatures on the Properties of Steel." One of the main points which was brought out in Dr. Langenberg's paper was his comparison of American nickel ordnance steel and the Krupp chrome-nickel ordnance steel. Both of these steels had the same tensile properties, but the German steel appeared far superior when tested by the Charpy test. It appears that the nickel steel does not have the stamina that the Krupp chrome-nickel has. He explained how the Charpy test is used in the inspection of materials in our army ordnance and how the defenses at the Panama Canal were amazingly

improved by the use of the proper materials, properly tested. Dr. Langenberg gave a very capable presentation which brought forth much valuable discussion.

The April meeting of the chapter was held on the 15th at which time J. A. Succop presented a most interesting paper, covering the shop practices of the Heppenstall Forge & Knife Co., Pittsburgh. This paper was illustrated with several reels of motion pictures taken throughout the plant.

The May meeting of the chapter was held on the 19th, which was the annual and final meeting for the year 1923-24. About 25 members assembled at the General Electric parking grounds at 5:30 p. m. and journeyed by automobile to White's Sulphur Springs Hotel at Saratoga Lake where a most enjoyable banquet was served, the cost for which was defrayed by the chapter. The speaker for this meeting was J. V. Emmons, metallurgist, Cleveland Twist Drill Co., who gave a very interesting paper on the subject of "High Speed Steel." Mr. Emmons reviewed briefly the history of high speed steel and its composition, methods of inspection and finally the methods of hardening. Following his presentation, Mr. Emmons was plied with many questions which brought forth interesting and helpful points of information, both from the experiences of Mr. Emmons and from the experiences of many of the members of the chapter. R. T. Bayless, editor of TRANSACTIONS, was also present and gave a short talk on some of the activities of the society and especially on those pertaining to the TRANSACTIONS. Chairman Merrick called upon S. L. Hoyt, secretary of the chapter for a report of the tellers of election who announced that the officers for the ensuing year had been duly elected, and are as follows: Chairman, B. H. Magill; vice chairman, A. C. Mengel; secretary-treasurer, James Taylor; chairman program committee, E. J. Edwards; and executive committee, A. W. Merrick and S. L. Hoyt. At 10:30 p. m., the meeting adjourned and the party returned to Schenectady by automobile.

## SPRINGFIELD CHAPTER

On Tuesday evening, May 13, the Springfield chapter of the American Society for Steel Treating held a meeting at the Highland hotel. Capt. D. G. McGregor, ordnance department, U. S. armory, addressed this meeting, choosing for his subject, "National Preparedness as Related to Industry." This was a very interesting presentation.

## SOUTH BEND CHAPTER

The South Bend chapter of the American Society for Steel Treating held a meeting on April 30 at the South Bend Y. M. C. A. T. Y. Olsen of the Tinius Olsen Testing Machine Co., Philadelphia, presented a paper on "Testing Equipment for All Kinds of Materials," which was very interesting and instructive. Report of the nominat-

ing committee was made, giving their selection for new officers for the ensuing year. These will be announced in the next issue of TRANSACTIONS.

## ST. LOUIS CHAPTER

The annual meeting of the St. Louis chapter of the American Society for Steel Treating was held on May 19, at the American Annex hotel at which time C. B. Swander, metallurgist, Wagner Electric Corporation, gave an interesting paper entitled, "Hardening of High Speed Steel Dies." The election of officers for the coming year resulted in the following elections: chairman, F. G. White, National Enameling and Stamping Co., Granite City, Ill.; vice chairman, Harry Lape, Ludlow-Saylor Wire Co., St. Louis, Mo.; secretary-treasurer, T. A. Oberhellman, Lincoln Electric Co., St. Louis, Mo. The Executive committee is as follows: L. T. Clark, Leschen Wire Rope Co.; St. Louis, Mo.; C. B. Swander, Wagner Electric Corp., St. Louis, Mo.; Alan Jackman, Firth-Sterling Steel Co., St. Louis, Mo.; G. S. Rogers, E. F. Houghton and Company, St. Louis, Mo.; and W. E. Buck, National Enameling and Stamping Co.; Granite City, Ill.

## TORONTO CHAPTER

The Toronto chapter of the American Society for Steel Treating held a meeting on April 25 at 8:15 p. m. in room 32, Mining building, University of Toronto. The speaker of the evening was Edgar C. Bain, research metallurgist, Atlas Steel Corp., Dunkirk, N. Y. The subject of Mr. Bain's paper was "Laboratory Examination of Tool Steel." This was a capable presentation and brought forth much valuable and instructive discussion.

## WASHINGTON CHAPTER

On Friday, May 16 at 8 p. m., the Washington chapter of the American Society for Steel Treating held a meeting at Hotel Harrington. E. C. Smith, chief metallurgist, Central Steel Co., Massillon, O., gave an interesting illustrated paper entitled, "Open-hearth Alloy Steel Practice." This lecture covered the general practice employed in the manufacture of high-grade structural alloy steels and the properties of the resulting products. Mr. Smith discussed the reasons for choosing methods described and some of the principal factors associated with the choice of various combinations of alloying elements. In addition there were discussed the types of service for which the various alloy steels are particularly well adapted. Annual election of officers was held at this meeting.

## WORCESTER CHAPTER

The Worcester chapter and the Boston chapter of the American Society for Steel Treating held a joint meeting on May 16 under

the auspices of the Worcester chapter. There were also present representatives from the Hartford, New Haven, Rhode Island, Springfield and New York chapters. Registration began at 2 p. m. at the Warren hotel, Worcester, from which place the party left to visit the plant of the Wyman & Gordon Co. and the south works plant of the American Steel & Wire Co., both plants being in operation. Dinner was served at the hotel at 5:45 p. m. A brief word of welcome was extended by G. C. McCormick, chairman of the Worcester chapter. He announced the names of the officers for the chapter for the ensuing year. H. E. Handy, chairman of the Boston chapter, then expressed thanks in the name of the chapter for the courtesy extended by the Worcester chapter. V. T. Malcolm, chairman of the Springfield chapter, expressed his appreciation of being able to attend the meeting and extended greetings from the Springfield members. The main speaker of the evening, Dr. Ancel St. John, Union Carbide and Carbon Research Laboratories, was then introduced and spoke on "X-Ray Examination of Metals." A very lively and interesting discussion followed, which extended into the late hours even though it had been a very long day. This was a most successful meeting with an attendance of over 200.

# ADDRESSES OF NEW MEMBERS OF THE AMERICAN SOCIETY FOR STEEL TREATING

EXPLANATION OF ABBREVIATIONS. M represents Member; A represents Associate Member; S represents Sustaining Member; J represents Junior Member, and Sb represents Subscribing Member. The figure following the letter shows the month in which the membership became effective.

## NEW MEMBERS

ADLER, ADAM, (M-5), hardener, American Pulley Co.; *mail* 4556 N. Colorado street, Philadelphia.

ATWOOD, C. W., (A-3), district representative, Norton Co.; *mail* 204 Grandview Terrace, Hartford.

BANNON, T. J., (M-5), Pacific Gear & Tool Co.; *mail* 1035 Folsom street, San Francisco, Cal.

BERRY, L. E., (M-5), overseer, U. S. Cartridge Co.; Lowell, Mass.

BIRD, MYRON, (M-5), member of firm, California Saw Works; *mail* 721 Brannon street, San Francisco, Cal.

BURNS, A. H., (A-5), salesman, Crucible Steel Co. of America; *mail* 542 Folsom street, San Francisco, Cal.

CARLIN, J. E., (M-6), chemist, Henry Souther Engineering Co.; *mail* 34 Sumner street, Hartford.

CLARK, A. W., (M-5), secretary, Vulcan Tool Mfg. Co.; *mail* 41 Liberty street, Quincy, Mass.

CONOVER, C. S., (M-5), chemistry instructor, Wentworth Institute, Boston.

CROOK, W. J., (M-5), construction engineer, Pacific Coast Steel Co.; also associate professor of metallurgy, Stanford University; *mail* Box 985 Standford University, Cal.

DALTON, R. P., (M-5), hardener, U. S. Cartridge Co.; *mail* 143 W. Sixth street, Lowell, Mass.

DEAN, W. J., (A-5), president, Cape Ann Tool Co., Rockford, Pigeon Cove, Mass.

DOMONOSKE, A. B., (M-10), associate professor of mechanical engineering, University of California, Berkeley, Cal.

DONAHUE, A. I., (A-3), salesman, Hawkridge Bros. Co.; *mail* 726 Commonwealth avenue, Boston.

DUNLAP, W. H., (M-5), purchasing agent, Horace T. Potts Co., Philadelphia.

FAVER, L. E., (M-5), Larkin Specialty Manufacturing Co.; *mail* 288 First street, San Francisco, Cal.

FLINTERMANN, E. D., (M-5), production and research in alloy department, Michigan Steel Casting Co., Detroit.

FOWLER, J. S., (M-5), metallurgist, Pacific Foundry Co., San Francisco, Cal.

FREEMAN, W. R., (M-5), purchasing department (steel), E. G. Budd Manufacturing Co., Philadelphia.

GEBHARDT, C. W., (M-5), engineer, Echlin, Sheeline and Echlin; *mail* 1369 Hyde street, San Francisco, Cal.

GEIS, F. R., (M-5), chief chemist, C. C. Kawin Co.; *mail* 573 Mission street, San Francisco, Cal.

GEORGESON, J. T., (S-5), president, Atlas Forgings Co.; *mail* 1501 E. Fifty-fifth street, Cicero, Ill.

GERLINGER, WALTER, (M-5), president, Gerlinger Electric Steel Castings Co., West Allis, Wis.

GORMAN, FRANK, (M-5), foreman, Heat Treating Holt Manufacturing Co.; *mail* 1326 E. Washington street, Stockton, Cal.

HAMILTON, W. C., (M-5), general chief chemist, American Steel Foundries, Granite City, Ill.
HARMON, J. J., (M-5), works engineer, Walworth Manufacturing Co., Boston.
HILL, THOMAS, (M-5), metallurgist, Best Steel Casting Co.; *mail* 365 Breed avenue, San Leandro, Cal.
HILT, S. W., (A-5), salesman, Midvale Co., San Francisco, Cal.
HOLT, LUTHER, (M-5), in charge of tools, Norton Co.; *mail* 12 Summerhill street, Worcester, Mass.
HORVATH, L. M., (Jr-4), draftsman, Studebaker Corp.; *mail* 1028½ E. Indiana avenue, South Bend, Ind.

JEFFRIES, R., (M-5), Mann Manufacturing Co.; *mail* 454 Golden Gate avenue, San Francisco, Cal.
JOHNSON, P. L., (M-5), Superintendent of dies, R. Wallace & Sons Manufacturing Co., Wallingford, Conn.
JOHNSON, S. S., (Jr-3), 524 Ridgeway avenue, Greensburg, Pa.
JUPPENLATZ, J. W., (M-5), chemist, Chapman Valve Manufacturing Co.; *mail* 204 Oak street, Indian Orchard, Mass.

KANDY, J. J., (M-4), assistant foreman, Buick Motor Co.; *mail* 746 Paterson street, Flint, Mich.
KEEFE, J. H., (M-4), lieutenant in navy, *mail* 1657 Thirty-first street, N.W., apartment 306, Washington, D. C.
KOEPKE, C. A., (M-6), assistant supervisor time study, Studebaker Corp.; *mail* 502 Victoria street, South Bend, Ind.
KRESSE, O. A., (M-5), melter, Columbia Steel Corp., Pittsburg, Cal.
KURTZ, D. E., (M-6), foreman machine shop and heat treating, Johnson Motor Co.; *mail* 1161 E. Indiana avenue, South Bend, Ind.

LEWIS, R. A., (M-5), general manager, Bethlehem plant, Bethlehem Steel Co., Bethlehem, Pa.
LUHISON, H. G., (A-5), secretary-treasurer, Foucar Ray & Simon Co.; *mail* 512 Folsom street, San Francisco, Cal.

MAHEU, A. J., (A-4), salesman, Wetherell Bros., Cambridge, Mass.; *mail* 95 Vera street, West Hartford, Conn,
MARSHALL, E. F., (M-2), foreman heat treating, Graham Bolt & Nut Co., Coraopolis, Pa.
MCANDREW, T. J., (A-5), district sales agent, Poldi Steel Corporation of America, Philadelphia.
MOLAMPHY, J. E., (M-5), rolling mill superintendent, Judson Manufacturing Co., Emeryville, Cal.
MOORE, J. C., (M-5), head of science department, Cass Technical High School, Detroit.
MORLEY, W. S., (M-5), instructor, department of mining and metallurgy, University of California, Berkeley, Cal.
MOSS, M. H., (M-5), hardener, U. S. Cartridge Co.; *mail* 102 Wannalancit street, Lowell, Mass.

OLIVER, P. W., (M-5), metallurgist, Springfield Armory, *mail* 195 Northampton avenue, Springfield, Mass.

PAGET, HOWARD, (M-5), chemist, Judson Manufacturing Co.; *mail* 424 Ellis street, San Francisco, Cal.
PATTERSON, T. J., (M-3), foundry superintendent, Columbia Steel Corp.; *mail* 248 E. Seventh street, Pittsburg, Cal.
PICKETT, DAVID, (M-3), heat treater, Farrington Manufacturing Co.; *mail* 82 Providence street, Hyde Park, Mass.

PORTER, P. A. (M-4), mechanical engineer, Morgan Construction Co.; *mail* 469 Grove street, Worcester, Mass.
PURDY, M. A., (A-5), manager, Milton, A. Purdy Co.; *mail* 15 Spear street, San Francisco, Cal.

RICARD, J. A., (A-5), salesman, Crucible Steel Company of America; *mail* 79 Prichard avenue, Somerville, Mass.
ROSS, A. J., (A-5), salesman, Crucible Steel Company of America, San Francisco, Cal.
RAMMEHBURG, J. J., (M-5), heat treater, Scullin Steel Co.; *mail* 3615 Blair avenue, St. Louis, Mo.
RANDOLPH, SMITH, (M-5), hardening and tempering department, Templeton Kenley Co.; *mail* 217 N. LeClaire street, Chicago.

SCHUCK, J. B., (M-4), 4124 Labadie avenue, St. Louis, Mo.
SHAW, W. W., (A-3), salesman, Colonial Steel Co.; *mail* 1440 Bryan Place Chicago.
SMITH, H. W. (M-5), president and general manager, Great Western Motors Inc., San Jose, Cal.
SPENGLER, H. C., (M-4), foreman, George H. Spengler Co., Rockford, Ill.
STRANCHEN, D. M., (M-5), tool engineer, Ritter Dental Manufacturing Co., Rochester, N. Y.

TERRILLE, ALAN, (M-5), metallurgical department, Pittsburgh Crucible Steel Co.; *mail* 117 Seventh avenue, Midland, Pa.
THOMAS, E. B., (A-4), salesman, Bethlehem Steel Co.; *mail* 273 Farmington avenue, Hartford.
THURSTON, S. R., (M-5), chemist, Bethlehem Shipbuilding Corp.; *mail* 1525 Edith street, Berkeley, Cal.
TURNER, E. J., (S-4), sales manager, McLain Fire Brick Co., Pittsburgh.

VAUGHAN, A. G., (A-5), salesman, Electric Furnace Co., Salem, Ohio.
VAUGHAN, S. E., (Jr-5), Stanford University, San Francisco, Cal.

WALTERS, H. E., (M-12), United Engineering and Foundry Co., Pittsburgh.
WARD, J. A., (A-5), district manager, Crucible Steel Company of America; *mail* 542 Folsom street, San Francisco, Cal.
WARNER, F. R., (M-5), toolmaker, Western Electric Mechanical Co., Oakland, Cal.; *mail* El Cerrito, Cal.
WATSON, S. C., (M-3), general manager, Columbia Machine Works and Malleable Iron Co.; Brooklyn, N. Y.
WATSON, W. S., (M-12), 191 Adelaide street, West, Toronto, Ontario, Canada.
WEIDMAN, E. J., (Jr-4), laboratory, Studebaker Corp.; *mail* 505 East Sample street, South Bend, Ind.
WELTY, G. D., (M-5), U. S. Aluminum Company, Cleveland.
WILSON, G. F., (A-4), district manager, Ludlum Steel Co., Philadelphia.
WILSON, W. L., (M-5), laboratory assistant, U. G. I. Contracting Co.; *mail* 1326 S. Fifty-sixth street, Philadelphia.

WILLIAMS, P. S., (M-5), chemical engineer, Standard Oil Co., San Francisco, Cal.

WINCHESTER REPEATING ARMS CO., (S-5), New Haven, Conn.

YOUNG, LAFE, (S-5), general superintendent, Laclede Steel Co., Alton, Ill.

YEATON, H. E., (M-3), melter, Columbia Steel Corp., Pittsburg, Cal.

ZIMMERMAN, J. H., (M-5), assistant instructor, Massachusetts Institute of Technology, Cambridge, Mass.

## MAIL RETURNED

ADAMS, ROBT. B., 2621 Dalton avenue, Los Angeles, Cal.
ADTIANCE, E. F., Axelson Machine Company, Box 316, Los Angeles, Cal.
BLUE, A. A., Duff Manufacturing Co., Pittsburgh.
CAMPBELL, L. A., 1041 W. Forty-eighth street, Los Angeles, Cal.
CARUTHERS, M. W., 1516 Grove street, Evanston, Ill.
DORSAM, A. J., 337 Atlantic avenue, Camden, N. J.
EARL, S. R., Angelus Steel Treating Company, Los Angeles, Cal.
JONES, J. J., 6 Sedalia St., Avalon, Pittsburgh.
LAPE, HARRY, 634 Newstead avenue, St. Louis, Mo.
LOOP, J. F., Oakland Automobile Company, Pontiac, Mich.
OSTERBERG, A. V., 743 Lincoln Way, East, South Bend, Ind.
SCHAAP, A. I., Jr., 292 Lincoln avenue, Brooklyn, N. Y.
SCHAFER, R. H., Textile Finishing Machinery Co., Providence, R. I.
SCHLACHTER, H., 4128 N. Maplewood avenue, Chicago.
SHIH, C. J., Box 151, Cambridge, Mass.
SOLBERG, F., 447 Maple avenue, Chicago.
SMITH, W. P., 244 Brown avenue, Turtle Creek, Pa.
STEWART, W. J., 400 Edgemont street, Pittsburgh.
SYKES, L., New York Shipbuilding Corporation, Camden, N. J.
WEBER, J. E., 709 Sixth avenue, New York City.
YOUNG, J., Ingersoll Rand Co., Phillipsburg, N. J.

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At such a time there is a tendency to buy material that invoices a fraction or so less and in the scramble for low prices final cost is forgotten.

Bohnite is an excellent example of the fallacy of such reasoning. An invoice for Bohnite probably will be slightly higher than an invoice for the same quantity of another material.

But over a run of several hundred tons of steel Bohnite will cost considerably less than even the other material *appears* to save.

For Bohnite has proved times without number that, since it goes into the furnace with its full strength it delivers a greater efficiency while it is in there.

Bohnite is not *cheap*, but it is remarkably economical in production *costs*.

## The Case Hardening Service Company

**2281 Scranton Road** **Cleveland, Ohio**

# Bohnite

## It's What You Get Out Of It That Counts

*THE*

# TRANSACTIONS

OF THE

*AMERICAN SOCIETY FOR STEEL TREATING*

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Issued monthly, $10.00 a year, $1.00 per copy

Entered as second-class matter, February 7, 1921, at the post-office at Cleveland, Ohio, under the Act of March 3, 1879

RAY T. BAYLESS, *Editor*

Vol. V June, 1924 No. 6

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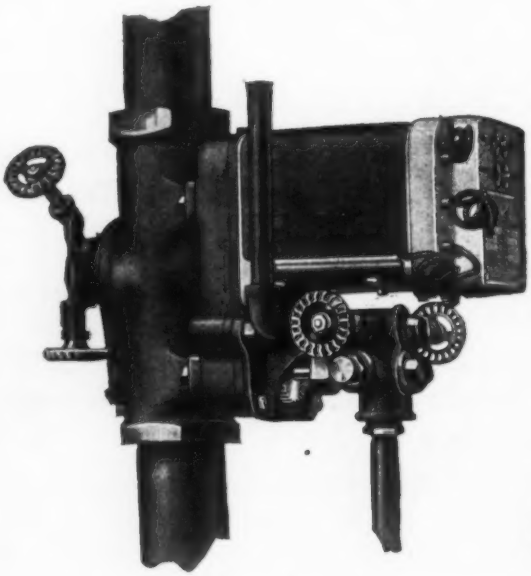

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# HEART TO HEART TALK WITH STEEL TREATERS

*By the President of*

*E. F. HOUGHTON & CO.*

I HAVE been requested to make the circulation policy of The HOUGHTON LINE plain to the members of the Society.

There seems to be prevalent the thought that we will mail gratuitously only one copy of The LINE to each company, and that the purchasing agent or chief metallurgist is entitled to that copy. This is not true. Any officer, purchasing agent, works manager, superintendent, department manager, shop foreman, metallurgist, chemist, mechanical engineer, stationary engineer, and any of their assistants, are entitled to be placed upon the mailing list.

All that is necessary is for someone to make the request in writing, giving the name in full, the P.O. Address, the identity of the company, and the position occupied. The person receiving the copy does not necessarily have to autograph the request. Any member of the Society may send us in a list of names of those qualified and sign the request for all of them, but the particulars as heretofore described must in all cases be furnished, otherwise the name will not be qualified.

One member of the Society wrote to me saying, "As I take it for granted you obtain your money back, covering the cost of The LINE from the benefits of the Heart to Heart Talks, I can't see what earthly benefit you can derive by mailing The LINE to our Stationary Engineer, because all of the Talks seem to refer to Heat Treatment Products, and the Engineer knows nothing about such products or their use, and it can do you no good to tell him about them."

It is a queer thing how we all believe we could run the other fellow's business better than he can run it, notwithstanding the fact that he may have made a success over a period of years.

There are issued each month 15 editions of The LINE. The editorial pages, indicated by the Arabic numerals, are alike in all editions. But the Heart to Heart Talks differ in each. The initial in the lower left corner of the front cover of The LINE indicates the edition.

Most metallurgists and heat treaters would find their copy marked "C-H" meaning "Casehardening," in which the Talks refer mostly to heat treatment subjects. The edition marked "M" means "Metal." The Talks in this edition refer to things in general in any metal working establishment, such as lubricants, rust preventives, cutting oils, belting, etc. This is the edition which would be mailed to the shop foreman, purchasing agent, etc. Your stationary engineer would receive the edition marked "P" meaning "Power," in which the Talks refer to topics pertaining to the power plant.

All you have to do is to furnish us the information and we will do the proper classifying.

Some steel plants have several hundred names on The LINE mailing list. The more the merrier, so far as we are concerned.

The larger the circulation the lower the cost per single copy of The LINE and the greater the margin we have from our annual appropriation, with which to improve its quality, so every reader of The LINE is selfishly interested in aiding us to increase the circulation, for it will help to make each copy he receives better in the future.

In introducing me to one of my audiences a few months back, the Chairman said, "The speaker of the evening requires no further introduction than the statement that he is the Near Editor of The HOUGHTON LINE, because every executive connected with American industry reads The LINE. Not to read The LINE is as unusual as not to read your local daily paper. We must read The LINE to keep up to the minute with events."

Rather flowery, don't you think? But then it is a fact that three times more industrial executives read The LINE than read any other publication covering only the industrial field.

Yours fraternally,

CHAS. E. CARPENTER,

*President of E. F. Houghton & Co.*

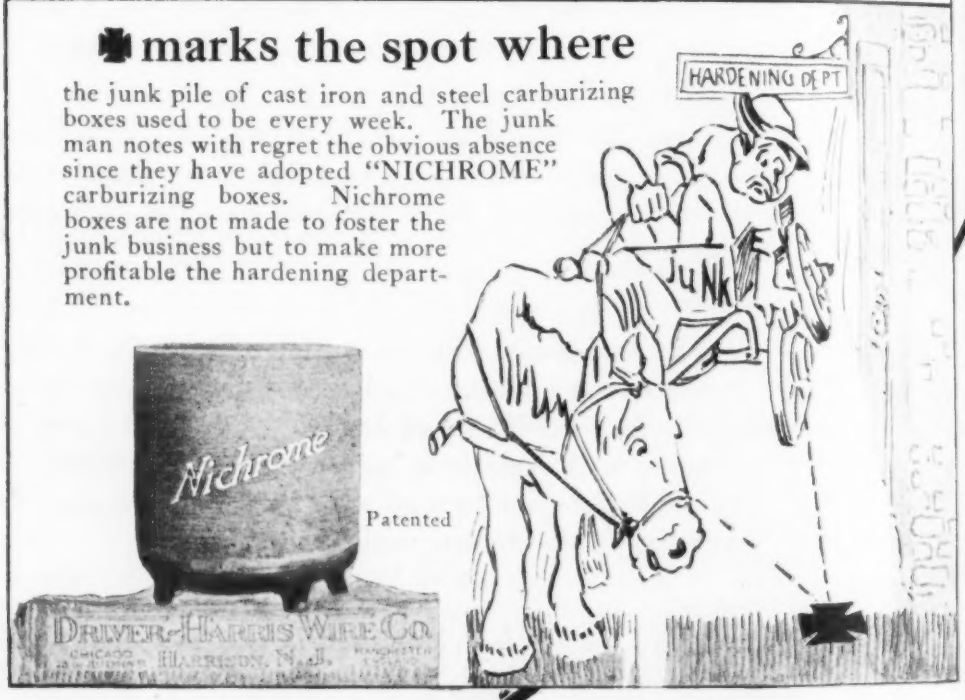
# Starting in 1916

The "*regretted* absence of the junk pile" is depicted below—reproduced from Metallurgical and Chemical Engineering of July 1916

94 METALLURGICAL AND CHEMICAL ENGINEERING JULY 15, 1916

**✠ marks the spot where**

the junk pile of cast iron and steel carburizing boxes used to be every week. The junk man notes with regret the obvious absence since they have adopted "NICHROME" carburizing boxes. Nichrome boxes are not made to foster the junk business but to make more profitable the hardening department.




**WE WILL** be glad to show you, by *performance records*, how more than 1200 users of Nichrome are now *enjoying* the absence of the junk pile—and the advantages of more uniform results.

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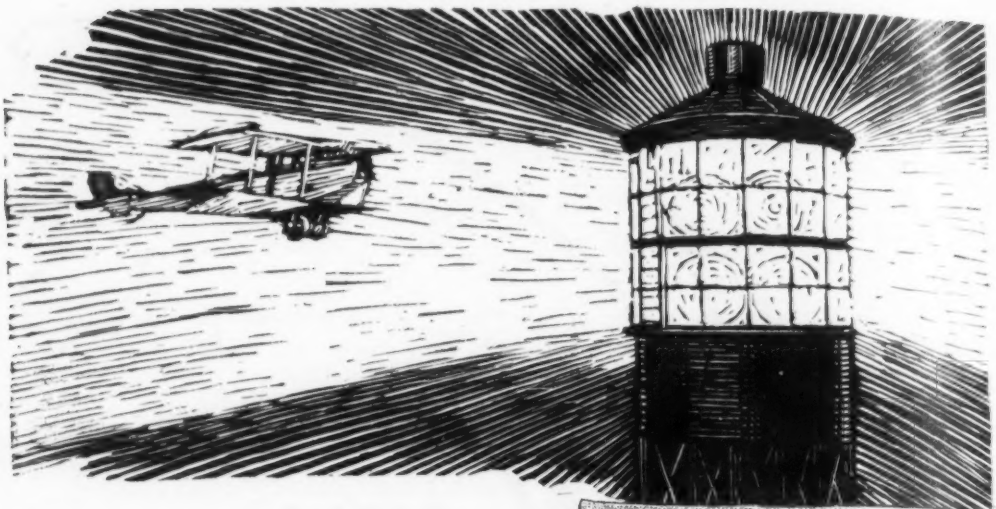
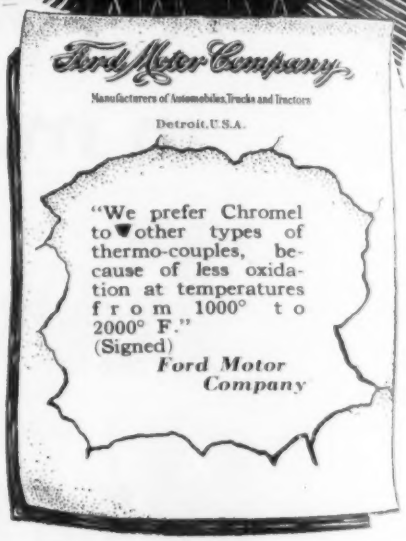


What is said to be the world's most powerful light house has recently been completed by the French. It crowns the crest of Mount Africia, seven miles from Dijon; it cost eight million francs and required two years to build. It serves as a guide for aviators flying between France, Italy and Algiers. It has a tremendous range of visibility—its eight arc lamps totaling one billion candle power.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Manufacturers of Automobiles, Trucks and Tractors
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(Signed)
Ford Motor Company

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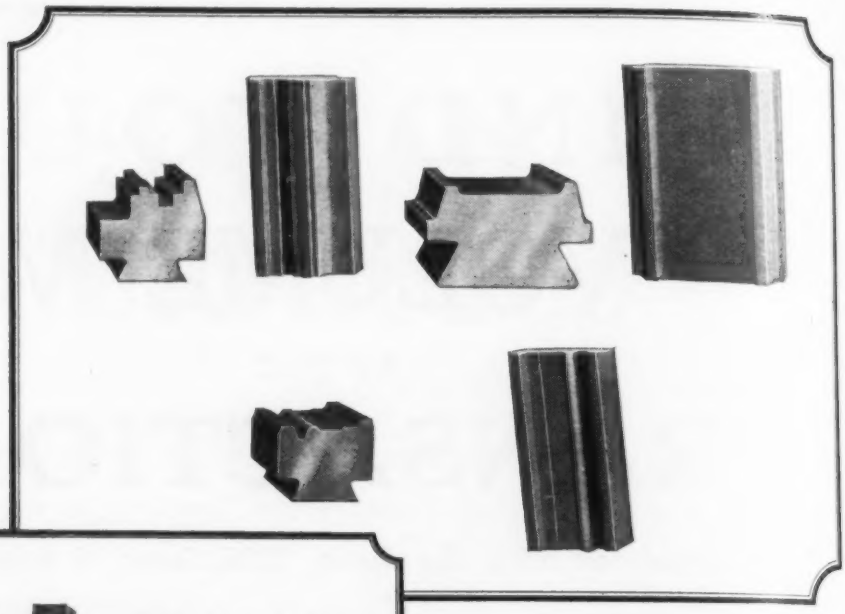
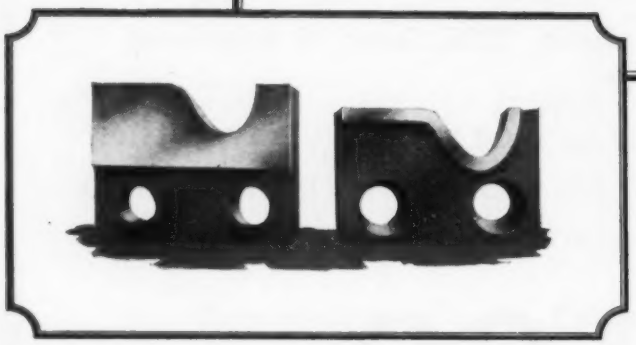
**4600 Prospect Avenue**

**Cleveland** **Ohio**



Group of Forming Tools made of Bethlehem Special High Speed Tool Steel.



Locomotive Tire Tread-Forming Tools made of Bethlehem Special High Speed Tool Steel. Bethlehem furnishes the steel, or the finished tread-forming tools, hardened, ready for use.

# For Forming and Finishing—

Bethlehem Special High Speed Tool Steel has proven its value for making forming and finishing tools for machining diversified metals—iron, steel, tool steel, screw stock, brass, bronze, etc.

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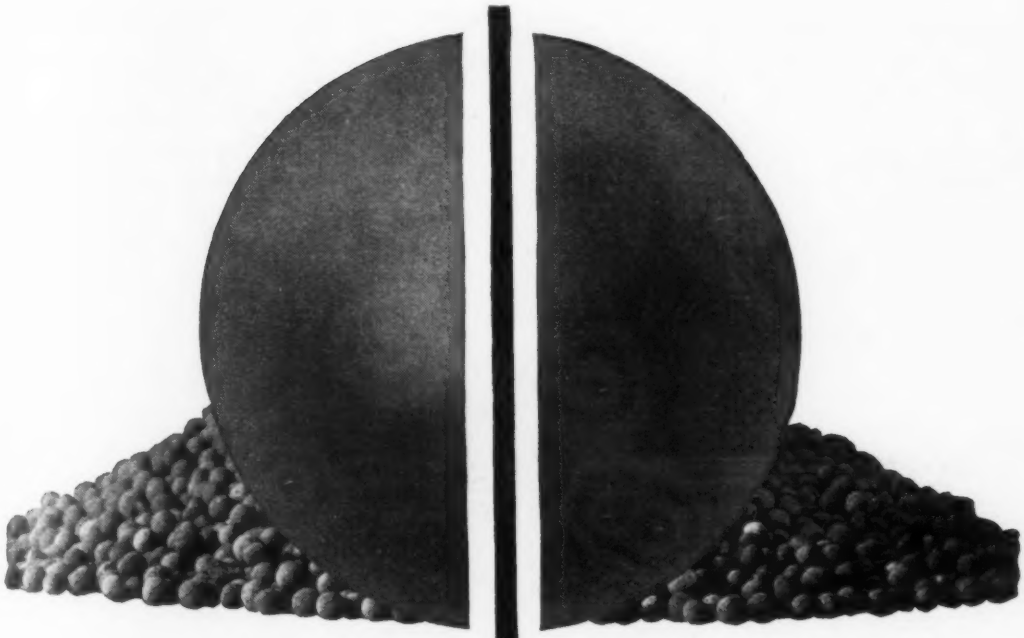

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Carbo is case hardening material through and through. It does not vary in composition or quality. Every shipment is alike—every pill alike. Hence it removes any uncertainties from the carbonizing operation due to the case hardening material.

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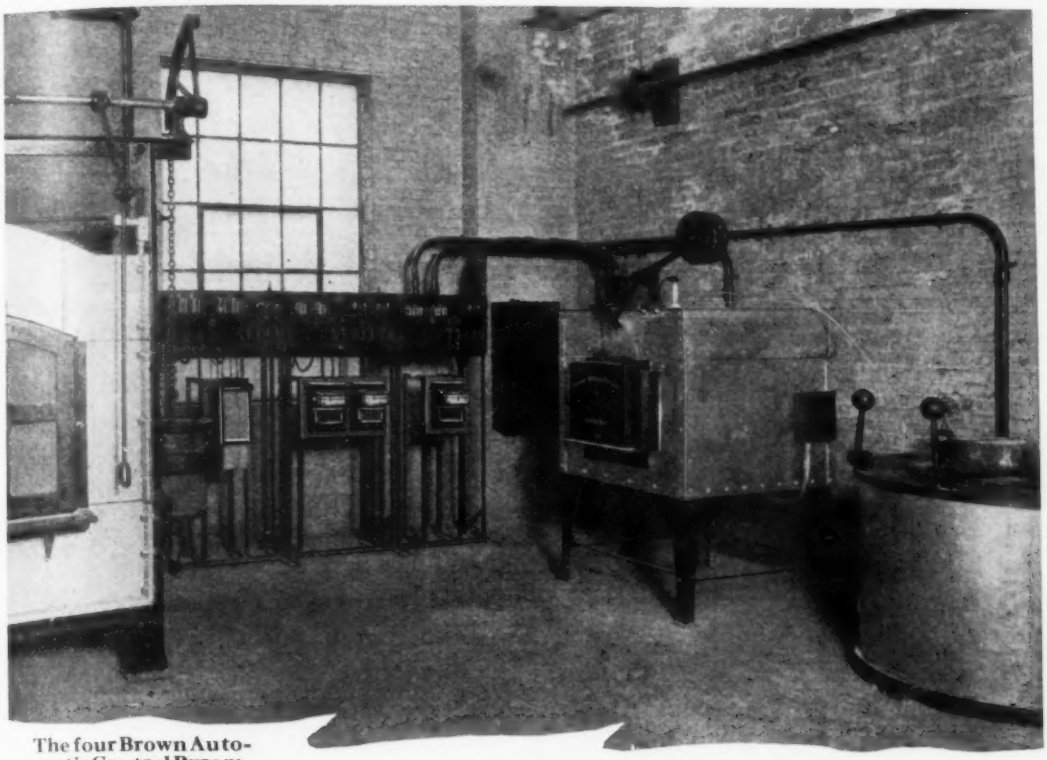
Cincinnati Detroit Chicago St. Louis



The four Brown Automatic Control Pyrometers at The Froiland Chain & Mfg. Co.'s plant.

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## *for Carbonizing, Hardening and Cyanide*

When the Froiland Chain & Manufacturing Company, Springfield, Mass. installed its new Electric Heat-treating Equipment—a Carbonizing Furnace, a Hardening Furnace and a Cyanide—Pot Furnace—four Brown Automatic Temperature Control Pyrometers were selected to measure temperature.

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Brown Automatic Control is applicable on all types of gas-fired, oil-fired or electrically heated furnaces. Wherever uniform temperature is the key to quality you will find that Brown Control is used profitably.

Write today for booklet "The Automatic Control of Temperature in the heat-treating of steel" and The Brown Automatic temperature control catalog No. 86. Address The Brown Instrument Company, 4502 Wayne Avenue, Philadelphia, Pa., or one of our district offices in New York, Boston, Pittsburgh, Cleveland, Columbus, Detroit, Chicago, St. Louis, Birmingham, Denver, San Francisco, Los Angeles, Montreal.

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**Most used in the world**

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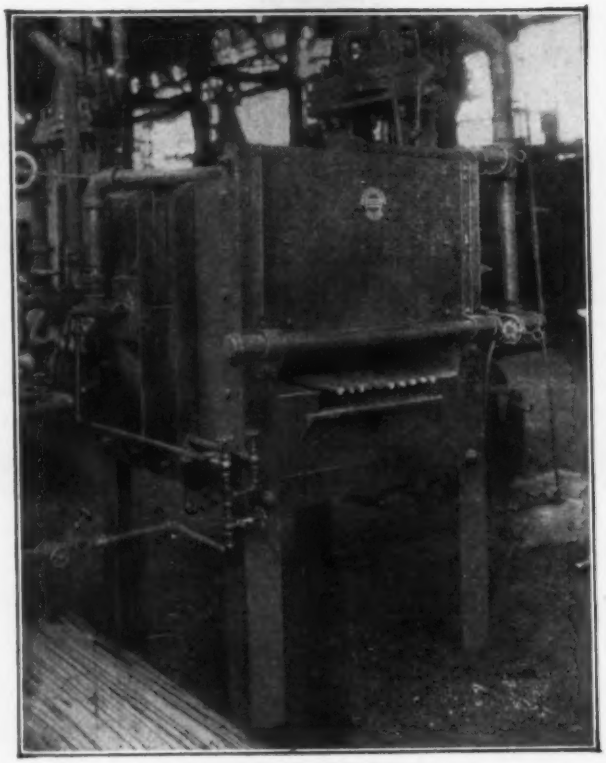

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It's the unbearable heat and gases from the old style forge—not merely the weather—which is responsible for the decreased production and higher cost when the men knock off with the excuse—"Too Hot to Work."

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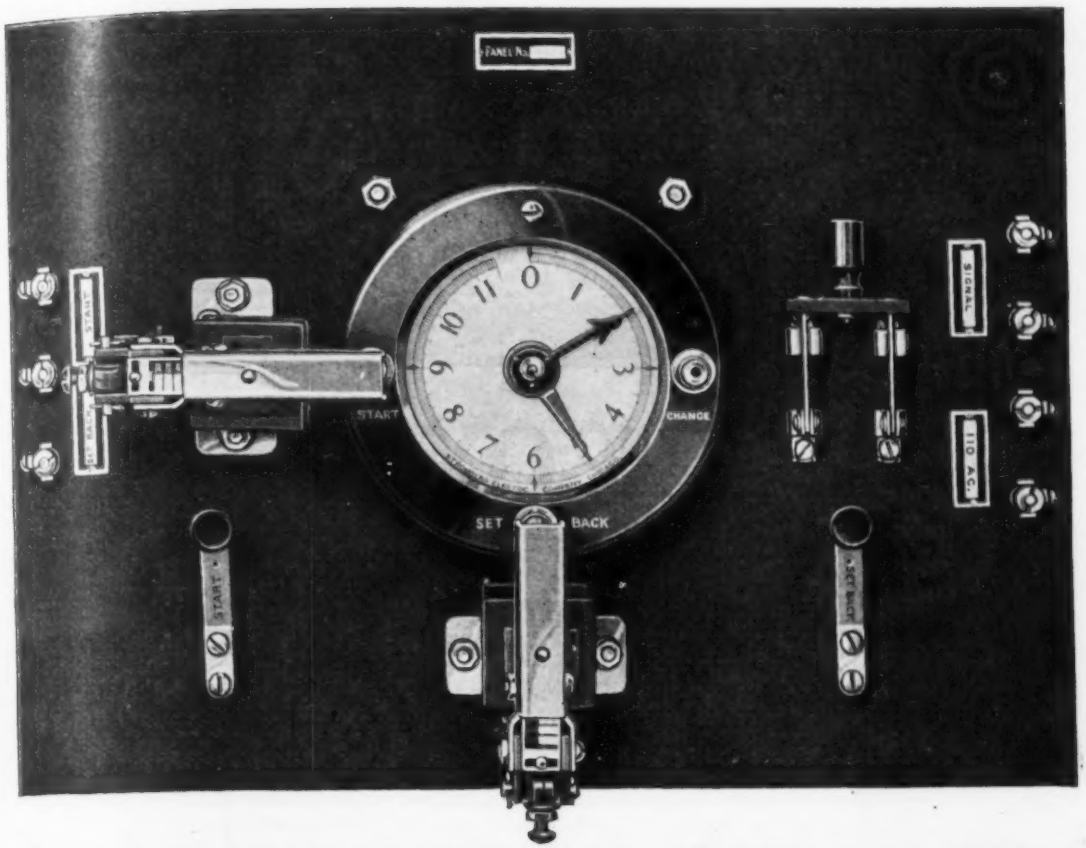


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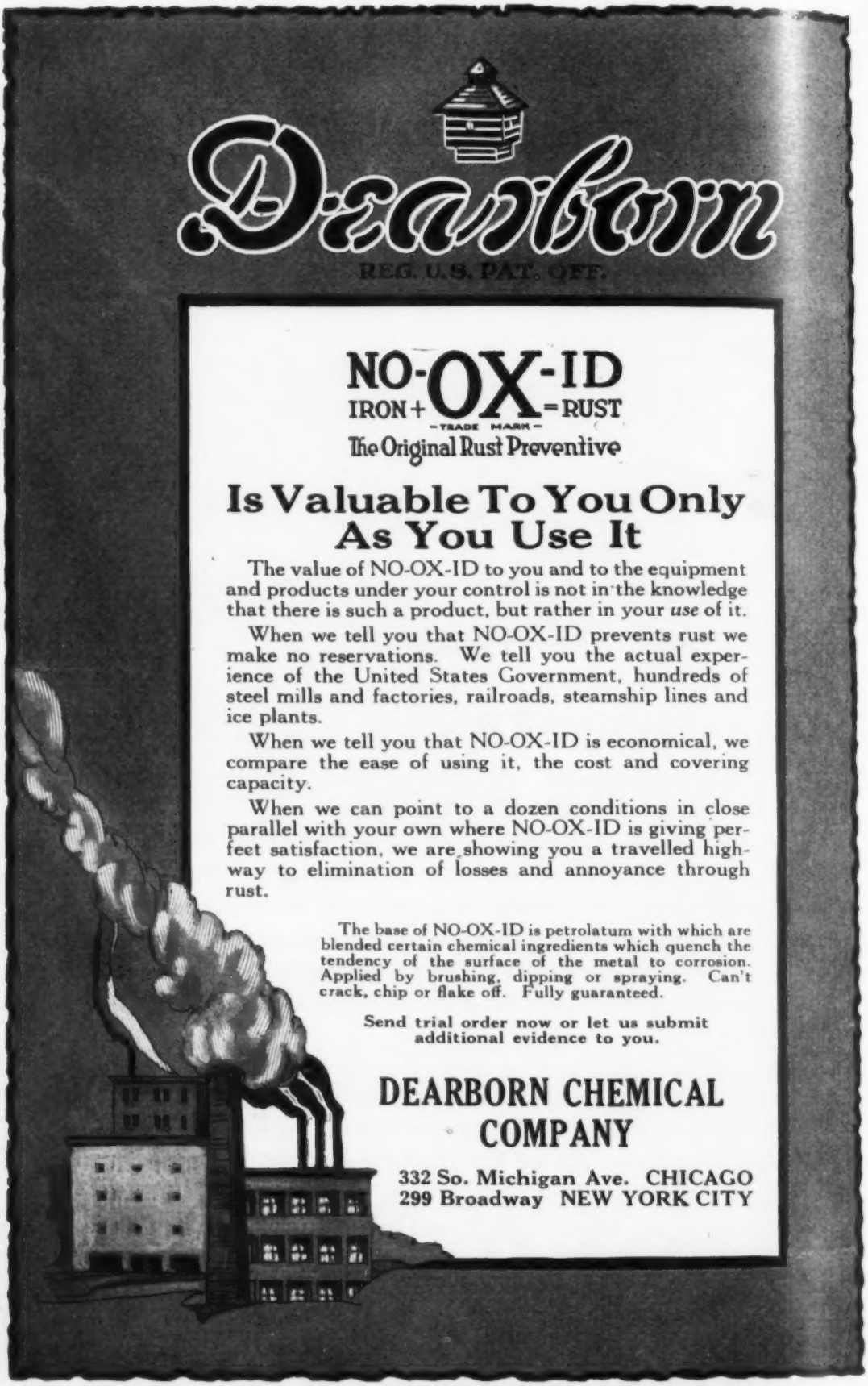
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The Original Rust Preventive
Is Valuable To You Only As You Use It
The value of NO-OX-ID to you and to the equipment and products under your control is not in the knowledge that there is such a product, but rather in your use of it.
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EMANUEL J. JANITZKY ..... 1922

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The Board of Directors of the American Society for Steel Treating has established a fund to be known as the Henry Marion Howe Medal Fund, the proceeds of which shall be used annually to award a gold medal to be known as the Henry Marion Howe Medal. The award will be made as follows:

(1) The medal will be awarded to the author of the paper which shall be judged to be of the highest merit. All papers in order to be considered must be published originally in the TRANSACTIONS of the Society during the twelve months ending August 1st of the year in which the medal is awarded.

(2) The competition for the Henry Marion Howe Medal shall be open to all.

(3) The award shall be made by the Board of Directors.

(4) The award may be withheld at the discretion of the Board of Directors.

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*The following firms and individuals, because of exceptional interest in the work of the Society have contributed not less than $25.00 each year for the promotion of its objects*

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This service is also for employers, whether you are members of the Society or not. If you will notify this department of the position you have open, your ad will be published at 50c per insertion in two issues of the Transactions. Fee must accompany copy.

**Important Notice**

In addressing answers to advertisements on these pages, a stamped envelope containing your letter should be sent to AMERICAN SOCIETY FOR STEEL TREATING, 4600 Prospect Ave., Cleveland, O. It will be forwarded to the proper destination. It is necessary that letters should contain stamps for forwarding.

## POSITIONS WANTED

MACHINIST with knowledge of metallography desires position. First class inspector with machine experience on machine tools and accurate automatic machine parts. Heat treatment inspection experience on tool steel and case carburized work. New England territory preferred. Address 6-10.

---

METALLURGIST or Assistant desires position in Philadelphia or New York district. At present employed. Four years shop experience in foundry and cupola control. Three years chemical analysis of ferrous and non-ferrous alloys. Supervision of heat treating, inspection and physical testing. One and one-half years as chemist and moulding foreman in steel foundry. Two years pyrometric and laboratory work on ball bearing steels. Technical graduate. Age 28. Single. Address 6-15.

---

METALLURGIST. Young man at present employed in Pittsburgh district, desires position with reliable firm that will present opportunity to learn. 6 years practical experience in heat-treating, pyrometry and physical testing of forgings, including marine, straight commercial, die blocks and drop forge supplies. Will furnish complete details of experience, first class references and reasons for making change. Location immaterial. Address 4-5.

---

METALLURGIST. Technical graduate desires position. 5 years experience in metallurgical and chemical work both ferrous and non-ferrous. Now employed by one of largest automobile companies in the country. Experience in laboratory work and shop troubles in heat treating, forging, carburizing, machining, etc. Also experienced in service complaints, experimental work and physical testing. Age 26 years. Detroit district or vicinity preferred. Address 4-10.

---

STUDENT graduating in June, 1924, having specialized in metallurgy and the heat treatment of materials, desires to make a connection with some industrial institution. Desires to follow the art of heat treatment. Address 5-10.

## POSITIONS WANTED

TOOL HARDENER desires position. Familiar with carbonizing and all tool steels. 10 years' experience. Can give first class references. Capable of taking charge of hardening room. Location in or around New York preferred. Address 5-15.

---

CHEMIST AND TREATER desires position where there is a chance for advancement. Location in Philadelphia or vicinity desired. Reasonable salary. Address 5-25.

---

## POSITIONS OPEN

WANTED graduate chemist with experience in metallography and heat treatment of large sections. Address 6-5.

---

WANTED YOUNG MEN. High grade men to travel through the great manufacturing and industrial districts to install, inspect and test electrical instrument and temperature controlling equipment. Special consideration will be given to applicants who have had experience in handling instruments, meters, gauges, recorders, controllers, etc. Educated men preferred. Unusual chance for promotion. Write, stating experience, education, age and salary desired. Address 5-5.

---

## FOR SALE

FOR SALE—12 brand new Engelhard recorders of the latest type, 1200 and 1600 degrees Cent. scales. Also 2 point automatic switches for converting into double recording machines. Prices reasonable. Address 5-20.

# Items of Interest

THE Bristol company, Waterbury, Conn., manufacturers of recording instruments and distributors of radio equipment, have leased 2740 square feet in the Larkin building, 3617 South Ashland avenue, Chicago, in order to adequately take care of the Middle West business, which has grown to large volume. Most of this area will be devoted to repairing and recalibrating Bristol instruments sold and used in the Chicago territory, but some will be used for stocking made-up instruments for quick deliveries and various lines of radio merchandise. The present salesroom and offices of the Bristol company will be maintained in the Monadnock building.

---

THAT more safety in coal mines has been the governing influence in the adoption of the research program for 1924-1925 at the Department of Mining Engineering at Carnegie Institute of Technology in Pittsburgh is revealed in the announcement of the five problems selected for investigation. Three of the five problems to be investigated next year, according to the announcement, are concerned, either directly or relatively, with mine safety.

Of special interest is the information that "Cost and methods of applying rock dust in commercial mines" will be one of the five major subjects for investigation. In view of the apparent acceptance throughout the mining industry in this country that "rock dusting" is the most efficient preventative of explosions so far invented, the decision by the Carnegie Tech authorities to enter this field of research is of far-reaching importance. The results of this study will doubtless be awaited with much interest because of the obvious unfamiliarity among American mining engineers regarding the effective uses of the "rock dust" theory.

Following the arrangements inaugurated three years ago when the co-operative mining courses at Carnegie Tech first entered the research field, five college graduates will be appointed this spring to begin the investigations in August of this year. Each of the Fellows will be assigned to a senior investigator representing the Pittsburgh experimental station of the United States Bureau of Mines. The co-operatve work of the educational institution and the Bureau of Mines will be supervised by an advisory board of coal mine operators and engineers which group selected the problems to be studied.

In addition to the rock dust research, the following problems will constitute the research program: (1) Relative explosibility of different sizes of coal dust in air; (2) Efficiency in blasting coal; (3) Friction losses in mine car trucks; (4) Underground loading devices. The study of "underground loading devices" will be financed by the Hillman Coal & Coke Co.

At the completion of the research work on these problems, it is further announced, full reports of the results obtained by the investigators will be published by the advisory board for distribution in the industry.

---

The Bethlehem Steel Corporation has recently issued the first of a series of

# Temperature

With the **F. and F. Optical Pyrometer** the temperature is measured by merely observing the object. It is accurate, simple, substantial and direct-reading.

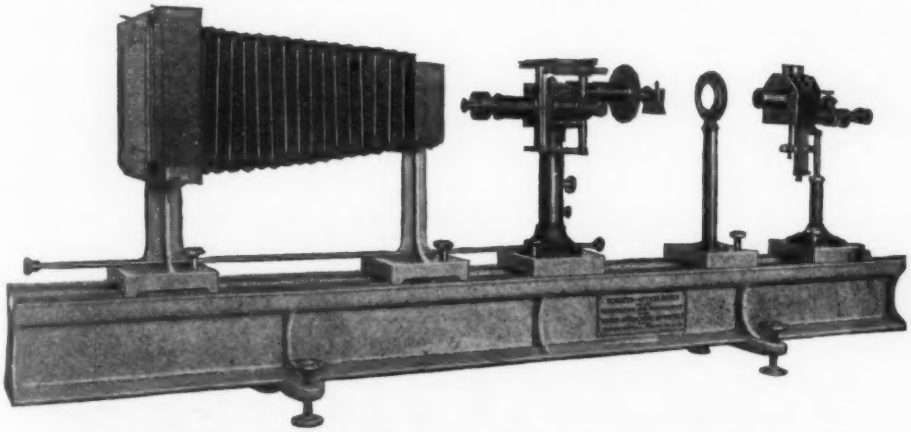
***(Write for Booklet)***

# Hardness

The **S. M. Co. Brinell Machine** is the standard machine for measuring hardness of metals and is used by the leading concerns.

Pressure is applied quickly and uniformly; a special feature prevents leakage of the hydraulic fluid.

# Micro-Structure



The **Scimatco Optical Bench** is the advanced outfit used by many of the foremost metallurgical firms for observing and photographing the micro structure of metals.

**SCIENTIFIC MATERIALS COMPANY**

*"Everything for the Laboratory"*

**PITTSBURGH, PA.**

news bulletins called the *Bethlehem Review*, designed to bring about among its employes a better understanding of management problems.

E. G. Grace, president of the corporation, says in the foreword of the initial number:

"It is most important to every Bethlehem employe that he know the facts about the problems which affect the Corporation's progress. A better understanding of these problems should tend to establish greater efficiency in production and lower unit costs. Efficiency in production and lower unit costs will mean steady work and pay for the Bethlehem employes, and will at the same time assure a fair return to the stockholders who have furnished the money to establish the business."

The first issue of the *Bethlehem Review* shows the employes the high cost of articles usually considered unimportant which are incidental to but necessary in the manufacture of steel, and points out the personal value to the employes of reducing to the minimum the waste of such articles.

In the following tabulation are some of the items often wasted in steel manufacturing. The figures show what the Bethlehem Steel corporation paid for these items last year:

| | |
|---|---|
| Soap | $ 8,161 |
| Paper Towels | 14,780 |
| Brooms | 17,255 |
| Window Glass | 25,855 |
| Shovels | 30,000 |
| Electric Light Bulbs | 200,000 |

---

The United States Civil Service commission announces the following open competitive examination for the positions of technologist, $3800 to $5000 a year; associate technologist, $3000 to $3600 a year; assistant technologist, $2400 to $3000 a year.

Applications will be rated as received until July 31. The examinations are to fill vacancies in the Bureau of Standards, Department of Commerce, at the entrance salaries stated above.

Applicants must select one, of the following optional subjects: Rubber technology, leather technology, paper technology, textile technology, oil technology, enameled metal technology, some special branch of technology not included in any of the above.

The duties of these positions comprise the application of scientific methods to industry; original investigations; development of processes and devices for the testing or treatment of materials; physical or chemical testing; and development of standards for rubber and related materials, leather and leather products, paper, textiles, lubricants and other viscous and plastic materials, enameled metal products, or other special or related experimental work.

Competitors will not be required to report for examination at any place, but will be rated on general education and experience, special education and experience in the optional subject selected, fitness, and writings to be filed with the application.

Full information and application blanks may be obtained from the United States Civil Service commission, Washington, or the secretary of the board of United States civil service examiners at the post office or customhouse in any city.

# SIMONDS
# Steel Mills

## Crucible and Electric Furnace Steel

## SHEETS and BARS

## Special Alloy Steel

We Develop Steels Required
For Particularly Hard Usage

# SIMONDS
# Saw and Steel Co.
## Lockport, N. Y.

John J. Crowe, for a number of years in charge of the testing and research laboratory at the Philadelphia Navy Yard, has resigned his position there to accept a position as engineer in charge of the apparatus, research and development division of the Air Reduction Co. at 100 Forrest street, Jersey City.

J. J. CROWE

Mr. Crowe has been a very active member of the A. S. S. T. and has played an important part in the progress of the society, having served as a member of the board of directors in 1921 and 1922, and has also served two terms as chairman of the Philadelphia chapter of the society.

---

The Perfection Tool Hardening Company, Chicago, formerly located at 1229 South State street, have moved into their new permanent home at 1742 West Austin avenue, and will be glad to have their friends visit them at any time.

---

It has been announced that the Harr Sales Company, Detroit, have been appointed exclusive sales representative in the state of Michigan and the city of Toledo, Ohio, for the Pittsburgh Instrument and Machine Company, of Pittsburgh. This company manufactures hand and power operated Brinell testing machines, Brinell microscopes and many other instruments for the testing of steel.

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E. B. Neil, formerly with the American LaFrance Fire Engine Company, New York City, is now located at 165 Broadway, Room 3121, in the capacity of advertising engineer.

---

Vanadium Alloys Steel Company, Latrobe, Pa., announce the removal of their offices from 143 Liberty street to 270 Madison Avenue, New York City. J. H. Roberts, eastern manager of sales, is in charge of this office.

# SPENCER TURBO-COMPRESSORS
give
# LASTING SATISFACTION

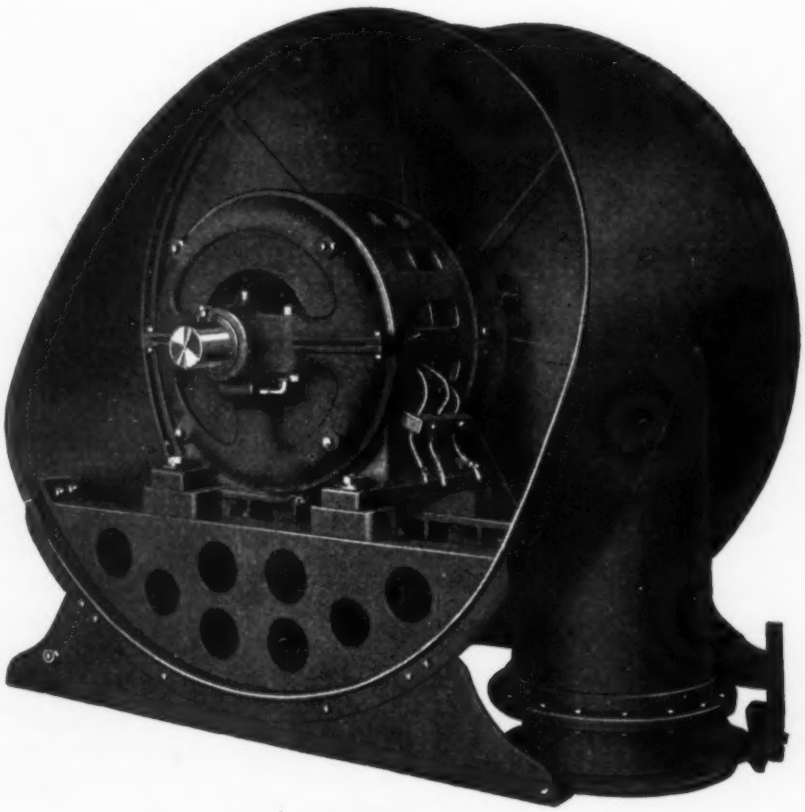
The Spencer line of Turbo-Compressors for 1 lb., 1½ lb. and 2 lb. pressures meets a wide demand for an efficient equipment of the "slow speed" turbine type for use in supplying air for oil and gas burning furnaces, foundry cupolas, etc.

It has no contacts nor even close clearances, hence no chance for wear.

It is a direct connected, self-contained unit, hence no belts, gears or chains with their resultant losses and noises.

It gives constant pressure with no pulsations and no surging.

The current consumption inherently decreases in proportion to reduction of volume of air used, eliminating all auxiliary governors.



**Motor End No. 1560 Turbo-Compressor**

## The Spencer Turbine Co.
**HARTFORD, CONN.**

***Ask your furnace manufacturer for details***

A definite program of investigations in metallurgy in co-operation with the United States Bureau of Mines was recently adopted by the Carnegie Institute of Technology in Pittsburgh as an extension of its ever-increasing field of scientific research, according to an announcement from Dr. Thomas S. Baker, president of the institution. Immediate action to initiate the metallurgical research has been taken by the establishing of four fellowships to begin investigations of problems in August, 1924.

The fellowships, says the announcement, will be awarded to college graduates, the appointees to register as candidates for the degree of Master of Science. Each will be paid a yearly stipend of $750.00.

The move to add metallurgical research to the program of investigations at Carnegie Tech is considered to be one of the most important decisions recently made in the Pittsburgh institution. In carrying out the work, the Institute will have not only the co-operation of the United States Bureau of Mines, but the financial aid and assistance of an advisory board of metallurgical engineers and steel manufacturers of Pittsburgh.

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At the annual meeting of the stockholders of the Firth-Sterling Steel Company held April 29, the following directors were elected: Lewis J. Firth, president; Eben B. Clarke, vice president; D. E. Jackman, treasurer; L. Gerald Firth and Thos. D. McCloskey. E. D. Gray was elected secretary of the company.

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The Leeds & Northrup Co., Philadelphia, have recently published the following: Catalog No. 75, entitled, "Apparatus for Electrometric Determination of Hydrogen Ion Concentration"; Bulletin No. 680, entitled, "Macbeth Illuminometer"; and Bulletin No. 871, entitled, "Temperature Measurements in Generators, Transformers and Cable Systems."

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John P. Roberts, formerly metallurgist with the Burroughs Adding Machine Co., Detroit, is now connected with the Cleveland office of the Wilson-Maeulen Co., in the sales capacity.

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E. H. Vogel has severed his connection with the Union Electric Steel Corp., Carnegie, Pa., and has accepted a position as sales engineer with the Witherow Steel Co., Pittsburgh.

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Bulletin No. 258 has recently been published by the W. S. Rockwell Company, New York City. This publication deals with the advantages of the Rockwell Air-Tight Blast Gate, and states that it is being used extensively for many difficult control operations in which expensive valves were formerly used. Further, it is preferred not only because of its low cost, but also its novel construction insures freedom from costly delays due to clogging and replacement of parts. It is air-tight, strong, and quick and positive in action.

Frederick Crabtree, head of the department of mining and metallurgy at the Carnegie Institute of Technology, has been elected to the presidency of the Engineers Society of Western Pennsylvania.

---

The Midvale Co., Nicetown, Philadelphia, has added Washington to the list of its district offices, its location being at Fifteenth and H streets, N. W.

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deCourcy Browne, Inc., formerly located at 120 Broadway, have moved their offices to 8 West Fortieth street, New York City.

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William J. Gambel Jr., of the Vulcan Steam Forging Co., Buffalo, N. Y., recently was elected president of the Engineering Society of Buffalo.

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Dr. Albert Sauveur, who is now sojourning in Europe, delivered a lecture on June 5 at the University of Grenoble, France. It is understood that at the time of his presentation he received a higher degree in acknowledgment of his important metallurgical researches.

It will be recalled that Dr. Sauveur received the Bessemer Gold Medal at the May meeting of the British Iron and Steel Institute, 1924.

**Automobile and other Alloy Steel Specifications are becoming more and more exacting**

It is necessary, therefore, to use the highest grade of raw materials entering into the construction of automobiles, machine parts, etc.

In the manufacture of our various metals and alloys, we must use, and do use, the highest grade of ores, oxides and aluminum.

| | | | |
|---|---|---|---|
| Tungsten Powder | 97–98% | Pure Chromium | 97–98% |
| Pure Manganese | 96–97% | Ferro-Tungsten | 75–80% |
| Ferro-Chromium | 60% | Ferro-Titanium | 25% |
| Ferro-Vanadium | 35–40% (1% Silicon) | | |

*Send for Pamphlet No. 2021*

**METAL & THERMIT CORPORATION**

Pittsburgh
Chicago
Boston

**120 Broadway, New York City**

S. San Francisco
Toronto

42 years of satisfaction prove that it pays you to use

R&H CHEMICALS

The best and cheapest basis for your

SURFACE HARDENING MIXTURE

CYANEGG R&H C Co TRADE MARK

**Sodium Cyanide 96/98%** guaranteed 51/52% cyanogen equivalent to 128/130% Potassium Cyanide

Add Soda Ash and salt as required for best results

---

As alternatives we offer

R & H Case Hardener (30%)
Special Case Hardening Mixture 43/45% lump or granular
Cyanide Chloride Mixture 73/76% in lump form

---

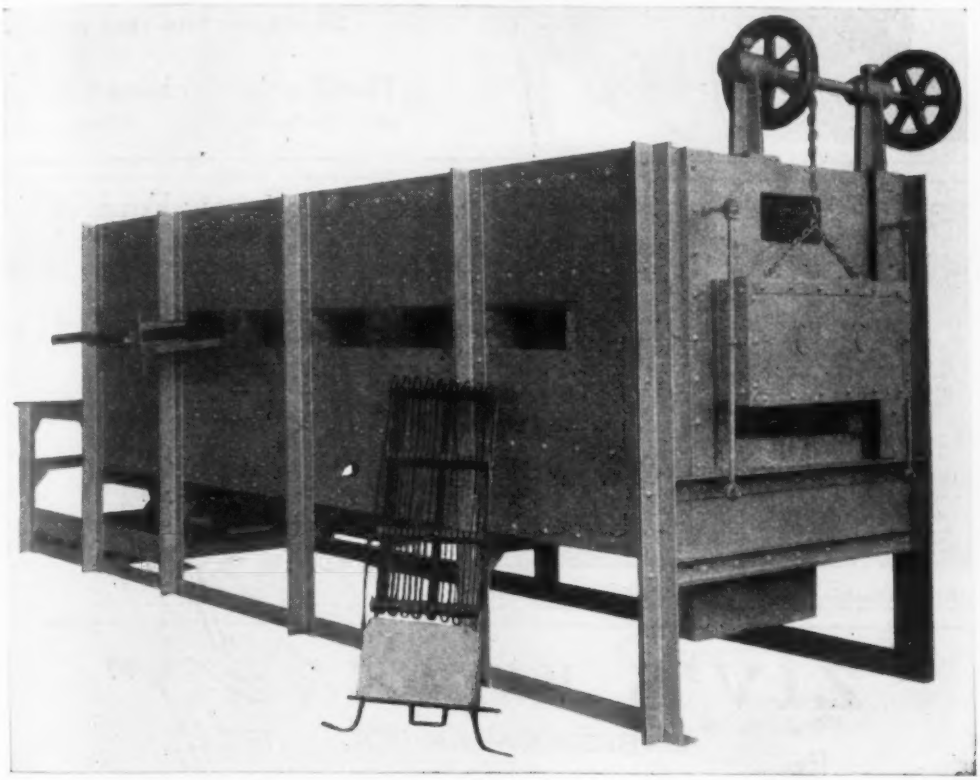
***Apply to us for technical assistance***

**The Roessler & Hasslacher Chemical Co.**

**709 Sixth Avenue** **New York City**

# HOLCROFT FURNACES

## THE STANDARD OF EFFICIENCY AND ECONOMY



62,000 Connecting Rods Weighing One Pound Each Have Been Heat-Treated in This Continuous Furnace at 1500°F. on 4940 K.w.h.

$$\frac{4940}{62.000} = .079 \text{ K.w.h. per Pound}$$

If Power Cost 1½c per K.w.h.
.079x1½c = $.00118 Cost per Pound.

The treatment is so uniform that the carbon content can be accurately estimated from the Brinnell hardness number.

**Units can be replaced in 20 minutes without interrupting production.**

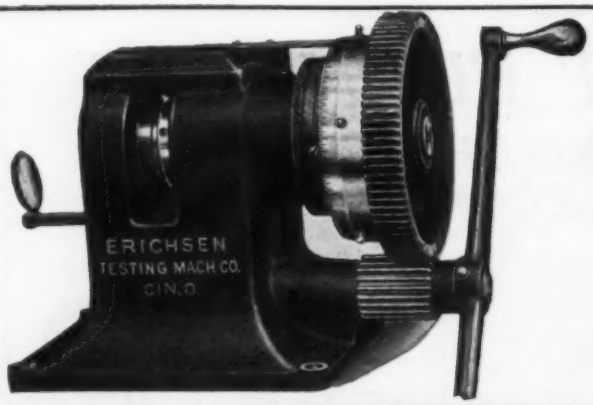
**We Also Build**

## Furnaces for Any *Fuel* or any *Capacity*

**Electric Melting**
**Open Hearth**
**Steel Annealing**
**Malleable Melting**
**Malleable Annealing**
**Electric Heat Treating and Annealing**
**Core and Mold Ovens**

# HOLCROFT & COMPANY

**6545 EPWORTH BLVD., DETROIT, MICH.**

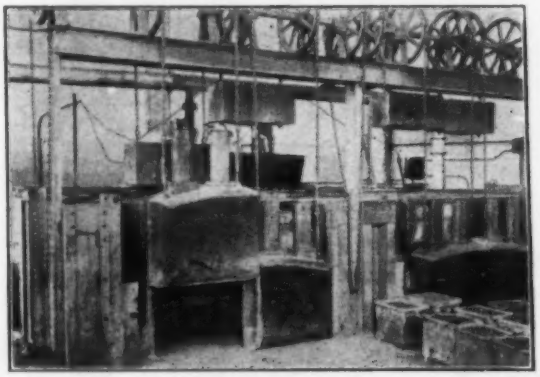



**Erichsen Testing Machines Standard the World Over**

For the Determination of the Drawing, Stamping, Compressive and Folding Qualities (the "Workability") of Sheet Metals.

**Know your Metal.**
**Save time and save money.**

**The Bock Machine Company**
**3618 Colerain Ave. Cincinnati, O.**



Built-in Double Chamber Carbonizing Furnace

F. J. Goodenow Furnace Co.

DESIGNERS AND BUILDERS OF

**INDUSTRIAL FURNACES**

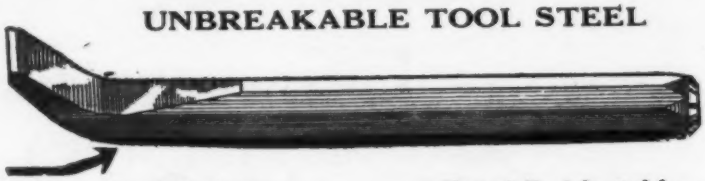
FOR ALL PURPOSES AND ALL FUELS

**Functional efficiency and freedom from repairs our strongest claim upon our customers.**

255 Meldrum Ave. Detroit

# ZIV'S "WIZARD"

**UNBREAKABLE TOOL STEEL**



After tempering, this point was bent cold, several times both ways without breaking.

Especially Adapted for
**Pneumatic Tools**

**ZIV STEEL & WIRE CO. 4423 W. Kinzie St., Chicago**

**"Things you may know, or may not, but should"**

# NEHTSCOS

Consider six popular case hardening steels as follows: S.A.S. 1112 or 1120; 1015 or 1020; 2315 or 2320; 3115 or 3120; 6120; and 2512. The following properties are tabulated from left to right in order of increasing magnitude:

| | |
|---|---|
| Costs of steel | 1—2—4—5—3—6 |
| Case hardness | 2—4—1—6—3—5 |
| Tensile strength | 6—3—5—4—2—1 |
| Impact strength | 6—3—5—4—2—1 |
| Machinability | 1—2—4—3—5—6 |

**NEW ENGLAND HEAT-TREATING SERVICE CO., INC., Hartford, Conn.**

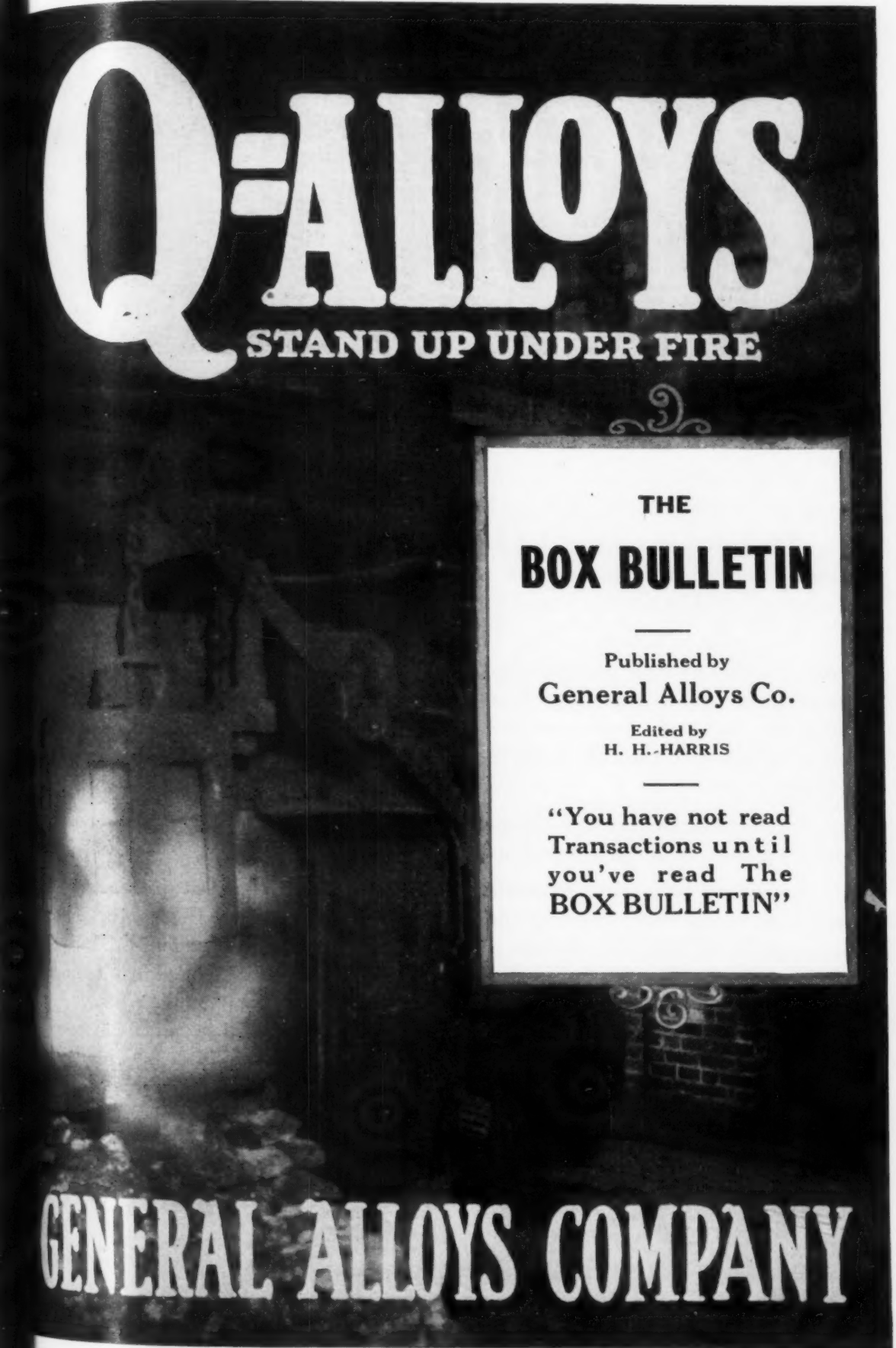
Agents for

**American Gas Furnace Co.**
**Wilson-Maeulen Co.**
**Rodman Chemical Co.**
**Duraloy Co.**

See advertisements elsewhere in this issue of TRANSACTIONS.

# Q=ALLOYS

STAND UP UNDER FIRE



THE

**BOX BULLETIN**

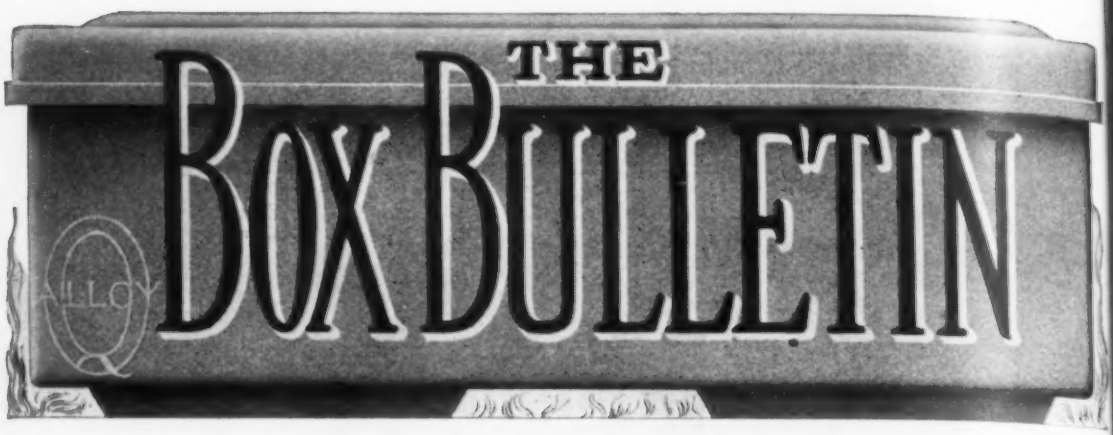
Published by

General Alloys Co.

Edited by
H. H. HARRIS

"You have not read Transactions until you've read The BOX BULLETIN"

GENERAL ALLOYS COMPANY




# HOW ABOUT IT?

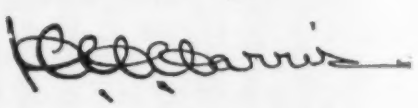
A Manufacturer's duty to himself and his trade does not end with the production of the best Product. It does not end with the sale of that Product.

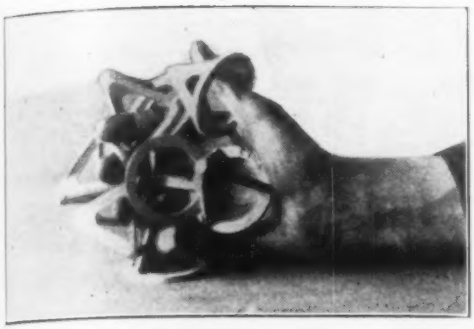
The greatest part of the sales work done by the manufacturer of any High Grade product is Educational or Missionary Work, which reflects directly for the good of the entire trade and to the benefit of Mankind in general.

The man who sells a High Grade and necessarily higher priced product must first convince a prospective buyer of the economic fallacy of buying and using lower quality cheaper products. His argument is a basic Economic doctrine, that better raw materials, better workmanship and better Engineering are cheaper in the end in any manufactured product from a Circus Tent to a Timber Hook.

He is doing his bit to Elevate the Processes of Industry, and the Thought and Engineering of his generation.

Less than 10% of all Mankind think, or work, in terms of precision. 1% would be nearer correct. Less than 20% of those who have the money, either individuals, or corporations really buy the higher quality merchandise. They are content to "Get By." Do You realize that apart from the work of individuals no man makes money except as he spends money to make money. Are you aware that more money spent for quality products will earn larger profits, almost without exception, than less money spent for low grade inferior products of any description. Some men build their houses to last for generations, buy their clothes to give years of wear, and in general possess a Greater Degree of Permanence—a Mental and Moral, as well as an Economic Superiority to those who lack foresight, and compromise with mediocrity.





# DO YOU CONSIDER UNIFORMITY AN ASSET?

The Uniformity of Q-Alloys, to the maximum extent that uniformity may be attained in a casting, is assured in Q-Alloys. The illustrations show furnace rails 28 ft. long, and a hand full of small castings made from the same analysis on the same heat.

# DO YOU CONSIDER THAT UNIFORMITY IS ESSENTIAL TO DEPENDABILITY?

When you test Q-Alloy yourself, or observe its satisfactory performance in some other plant you may be sure that this performance will be duplicated under similar conditions. Some of the largest heat treating plants in the world run to schedule with Q-Alloy MACHINERY which functions perfectly at a very high temperature.

# Q-ALLOYS ARE UNIFORM AND DEPENDABLE

# MIDNIGHT AIR
# NEW ENGLAND ROADS
# YOUR SEPTEMBER VACATION

Barring the aroma of a New England dinner, there is nothing that fits my nostrils like the smell of burning gasoline on the midnight air. Fritz agrees with me, there's nothing like it. The grand and glorious sensation of miles of road slipping along beneath you, that delectable fragrance in your nostrils, and the purr of contented cylinders in your ears, is simply incomparable. Every dog may have his day, but give me my nights on the highway, where towns slide by evenly and frequently, and State lines are merely incidents. Some say the joy of Touring is gone, but they are the unfortunate ones who do not know our Eastern roads, our Mountain Highways, and our Boulevards by the Ocean. They have never traveled as we travel.

Are you going to DRIVE EAST in September for the Steel Treaters Show in Boston? If not, Why Not? Do you know of a more agreeable, or a less

expensive Vacation than a trip to Boston in September? Do you know of a better Season to Drive? Do you realize how easy it is to travel 300 to 400 miles a day on all roads East of Buffalo? Do you realize that you can ship your car from Detroit to Buffalo, saving 350 miles, for approximately $18, and that fine staterooms on the giant D. & C. Boats cost less than hotel accommodations. Leaving Detroit at 6 P.M. you reach Buffalo at 8 A.M. It is 5 hours easy drive to Syracuse. It is 5 hours drive to Albany from Syracuse. All paralleling the Route of the famous Twentieth Century Limited. From Albany you cross the Hudson River taking a beautiful scenic road through Pittsfield to Springfield, and along the Boston Post road through Worcester to Boston. (Approximately 7 hours). We cover this route, and the route from Pittsburgh through New York to Boston several times a year, using the Boulevards in preference to the Railroads. This is written from Cincinnati. The roads from Cincinnati, Indianapolis, and points West are excellent. We are motoring to Chicago, Milwaukee, and adjacent points, and then back to Boston. We will return again and complete another round trip before the Show.

Anyone writing the Boston, Detroit, or Chicago Offices of the General Alloys Company will receive reliable road information. Five of our men, and a few dogs are covering the roads regularly. Seriously, we urge you to consider taking your Vacation in New England. You can kill 2 birds, or more, with a single rock. The opportunity may not again present itself. *Think it over.* DECIDE TO COME EAST BY MOTOR.

—BISMARK.


## To Our Friends and Customers

**We have made tentative reservations in all of the leading Boston hotels for the week of September 22. We have definitely reserved a number of rooms in the following hotels which we recommend:**

| | | |
|---|---|---|
| **Copley-Plaza** | **Lennox** | **Somerset** |
| **Westminster** | **Brunswick** | **Vendome** |
| | **Copley Square** | |

**This is done to insure our friends and customers of satisfactory accommodations in Boston during the Steel Show.**

**Kindly advise us at the earliest possible moment how many rooms you wish for your representatives who will attend.**

**Give dates and names if possible, also please advise hotels you prefer or rates desired. We'll do the rest.**

# The Tale of Loofmad, Maker of Mouse Traps

## By KRIT ICKLEPOINT

ONCE upon a time, there lived a man, Loofmad, by name, the son of a Cheesemonger, who was bound in apprenticeship to a mighty maker of Mouse Traps, that he might learn the secrets of this ancient trade.

Having toiled unceasingly in the pursuit of his honoured craft he was in time rewarded by admission to the Guild of Snare Smiths, and set forth to glean his rightful share of the world's treasure.

Being of no mean talents, and not unmindful of his duty to posterity, Loofmad conceived the vision of a more perfect Mouse Trap than ever yet devised by man. A still small voice within him said "Loofmad, go ye forth and seek thy fortune—but tarry not in the Bazaars of Bagdad, or the Cabarets of Cadiz. Pass ye by the comely maidens, tarry not in tempting tap rooms, but seek ye the solitude of the forest, and there construct thy meritorious mouse trap. Make ye a better trap than thy neighbor, and the world will beat a path to thy door."

Deep into the forest went Loofmad, and there fabricated the finest, the most perfect, and the most beautiful mousetrap known to man. Then he set himself down to wait for the world to beat the path to his door.

Loofmad waited, and it came to pass as predicted that the world beat a path to his door. No single day there bowed unto the setting sun, but that a score of visitors had come. The portal of his habitat he fitted with a coco mat, with "Mizpah" 'blazoned in the center, to bid all comers "Welcome-Enter." The rhythmic tread of hurrying feet soon wore the path into a street. And Loofmad's stenog took the cards of men from every clime, who'd traveled in from far and wide to take up Loofmad's time. They came to sell him maps and booze, comptometers and pencils—Machines for posting up his books, machines for cutting stencils. They wanted to insure his health, write Workmen's Compensation, sell him a car of apple sauce, Collect On Destination. The Agent for the publisher of "Safe Unlisted Stocks," preceded a Chronologist selling synchronized Time Clocks. The Mouse Trap Maker's Union had a deligation there—to see that Loofmad's hired hands were treated fair and square. A Federal Tax Inspector came to check up his return. Another bird sold sheet iron safes, "The contents cannot burn." "A Sailor" selling Panamas that he had "Smuggled" in. A Bootlegger with samples of some paint removing gin. The check protector salesmen came in droves and did their stunts. There were Muscle Shoals promotors sporting million-dollar fronts. The Postman sold him tickets to the letter-carriers ball. The Pastor of his church dropped in on a financial call. A dozen of his relatives, thot he was making dough and sent him collect telegrams with lengthy tales of

woe. The Salesmen came by thousands in a never-ending train, and Loofmad's nerves were shattered, he was suffering from the strain.

It also should be mentioned, Loofmad got a stack of mail. Everybody seemed to write him that had a thing for sale. He got letters from professors, who advised, if he were thin that they could give him secrets that would put more weight on him—But—if he happened to be stout and wanted to reduce, that they would send him pellets to pry the fat cells loose. He got letters offering courses in Dairying, or Law, and letters quoting special rates on barrel lots of slaw. He was urged to take up music, learn to play by ear by mail. He was warned of falling arches, of his Go-Glands getting stale. One Institute gave lessons, in the home, on "How to Swim,"—another gladly offered to make a "Pivot Man" of him. They sent him weekly Bulletins to digest where he sat, which if he read them carefully would make him a Pluto-crat. The proper use of "Will-Power" would make the Buyer Buy for him. The Proper use of "Man-Power" would make the Maidens cry for him. In the meantime Loofmad labored hard, and piled the Mouse Traps high, but not a single buyer hunted Loofmad up to buy. The Public didn't beat a path to purchase Rodent Snares. But smarter men came there to tell the merits of *their* wares.

The Mouse Traps didn't sell themselves, and Loofmad couldn't pay the scores of Bill Collectors who dropped in every day. The Landlord came to dunn him for long neglected rent. His sweetheart quit him cold because he didn't have a cent. His creditors descended, debts engulfed him like a flood, and a dozen money lenders were howling for his blood. The Sheriff finally sold his stuff, and tossed him out the door.

Sick and disheartened sat Loofmad*, as he pondered o'er his plight.

"I guess," said he, "I've headed Left, I haven't headed right — But, I have learned a lesson a costly lesson too, and as one Mouse Trap Maker to another, I'll pass it on to you."

Merit alone won't sell your stuff,
Matter not how well you make it,
The Buyer will not hunt you up,
Come search you out and take it.

You must take the buyers as they come
Some few are smart, but more are dumb,
Preach long and loud, the Basic theme,
That Quality will stand supreme,
That buying for economy
Is buying Basic Quality.

The Better men the Better things,
Comprise a small Minority,
So that is Selling Quality,
You're bucking the Majority.

Concentrated Quality, is concentrated energy
Both Mental and Physical, so thoroughly economica l
By ratio of the Brain to Bulk is how God grades the animal
By ratio, too, of Power to Mass, are rated things Mechanical.

In Concentrating Power to Mass, our Labours are Constructive
In diluting effective Force, Our course is most Destructive

In adding thought to conserve Force we really Concentrate it
Energy is not confined to Mass, to Man, or time
The Force of Mass and Mind is readily combined, man rates, he does not make it.
Energy is indestructible, no matter how you take it.

Q-Alloys combine the Energy of pure metals, the physical labor of able men, Electrical Energy, and the mental energy of our organization in a common constructive force to your advantage.

—KRIT

*P. S.—Spell backward.

# Q-ALLOYS

*Most Economical and Efficient Materials*

For CARBONIZING BOXES
ANNEALING BOXES
CYANIDE AND LEAD POTS
FURNACE PLATES
MUFFLES AND RACKS
TUBES AND RETORTS
CONVEYOR FURNACES
GLASS ROLLS AND DIES
ANY PARTS

*operating between 1000°F. and 2200°F.*

# GENERAL ALLOYS COMPANY

## BOSTON—27—MASS.

**CHICAGO**
122 So. Michigan Ave.

**BOSTON**
168 Dartmouth Street

**NEW YORK**
26 Cortlandt Street

**DETROIT**
General Motors Building

**CLEVELAND**
2281 Scranton Rd.

**INDIANAPOLIS**
Merchants Bank Building

**ROCHESTER**
921 Granite Building

**TORONTO**
191 Adams St.

**ST. LOUIS**
1517 Olive St.

*When answering advertisements please mention "Transactions"*

# To the Members

Please advise us of your last change of address so you may have prompt receipt of the Society publications. Make it possible for us to give the service that you expect and we want to give.

*Fill the form below and mail today*

American Society for Steel Treating, .....1924
4600 Prospect Auenue,
Cleveland, Ohio.

Gentlemen:

Please check my address record and change it to agree with the following:

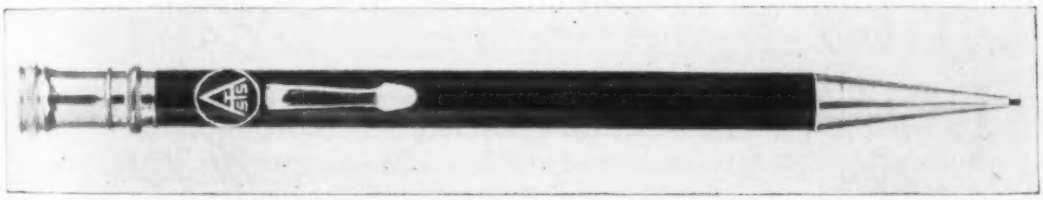
Name .....

New Mail Address .....

Business Address .....

Position or Title .....

Old Address was .....



The NU-TYPE is the most beautiful and artistic pocket pencil on the market. In construction, in artistic finish, and design, in its sturdy wearing qualities it endears itself to its users. It is a "different" pencil, and a better pencil.

The barrel is made of light, hard, enduring rubber composition which takes a very handsome finish. The rubber barrel is, in turn, reinforced with a metal tube which, by its special design, insures a splendid combination of strength and lightness.

A common defect in other pencils of this type is the ease with which the leads break in feeding through the tip. This defect is remedied by a specially constructed tip and by the dual gripping action on the lead.

NU-TYPE is known as "The Panel Pencil." The panels, clips, nuts, as well as the tips and caps, are made of 14k gold filled. These panels are attached to the pencil, just above the clip, a patented feature, and are engraved with the A. S. S. T. emblem.

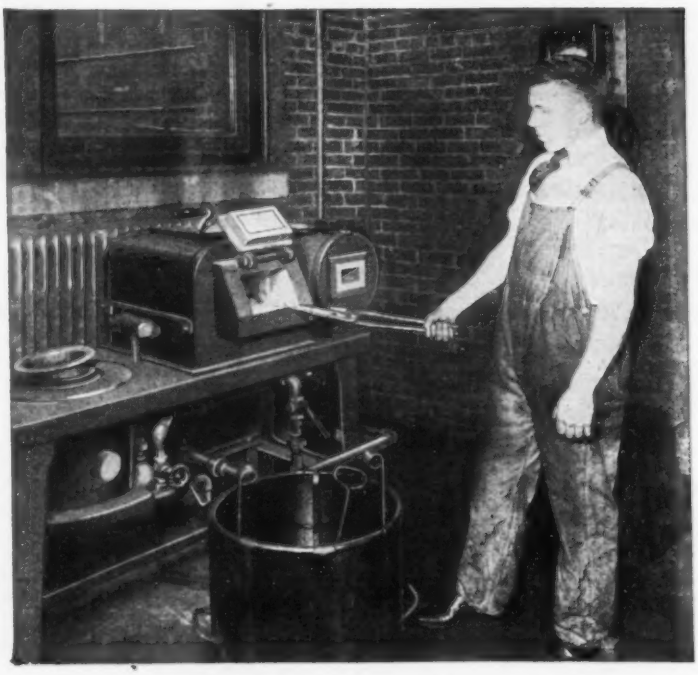
**PRICE POST PAID**

**No. 150—Octagon Barrel, 5¼", Panel lock and A. S. S. T. clip, 14k Gold Filled .....$3.25**

## American Society for Steel Treating

**4600 Prospect Ave.** **Cleveland, O.**

# Stewart Industrial Furnaces for Technical School Requirements



Stewart Triple Purpose Furnace in Pratt Institute, Brooklyn, N. Y.
Oven, high Speed Steel and Crucible Furnaces on One Base

EXACTING TESTS determine the worth of technical school equipment. Heat treating equipment, especially, must be thoroughly accurate and trustworthy. No chance for "bluff" or "camouflage", particularly in laboratory work.

The roster of schools using Stewart Industrial Furnaces reads like a directory of the universities and technical schools of America.

As the work of these schools is enlarged, they keep adding Stewarts —evidence that Stewart performance is entirely satisfactory.

In the industrial field the Stewart service record is just as creditable. There is a Stewart for every industry in which heat treating is a factor.

## Chicago Flexible Shaft Company

**1144 South Central Ave., Chicago**

16 Reade St., New York City, N.Y.
608 Kerr Bldg., Detroit, Mich.
2024 Ry. Ex. Bldg., St. Louis, Mo.
943 Granite Bldg., Rochester, N. Y.
768 Mission St., San Francisco, Cal.
1200-01 Standard Life Bldg., Pittsburgh, Pa.
1738 Nineteenth St., Milwaukee, Wis.
Room 305 Wesley Bldg., Philadelphia, Pa.
79 Milk St., Boston 9, Mass.
414 Elm St., Cincinnati, Ohio

Canadian Office and Factory: Flexible Shaft Co., Ltd., 349 Carlaw Ave., Toronto, Canada

## "American" Electric Pot Furnaces

For Cyanide—Lead—Salts
White Metals

Made in All Sizes—Round and
Rectangular

Automatic Control

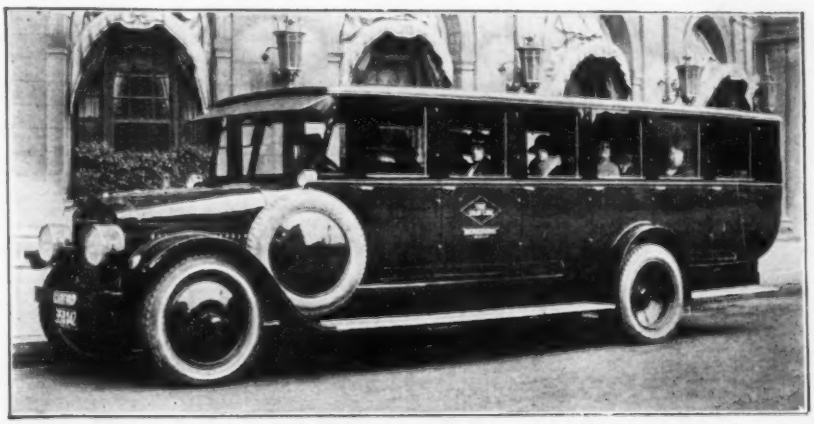
Temperature Range
400° F. to 1800° F

## American Metallurgical Corporation

168 Dartmouth Street Boston, Massachusetts

## The Best Way to See Boston Is By the Gray Line

***Eleven Different Tours***

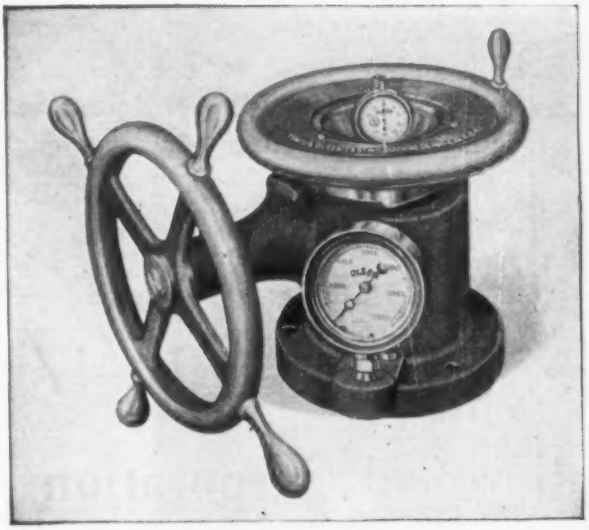


**Main Starting Point—COPLEY-PLAZA HOTEL—Copley Square**

Nowhere in America are Traditions Richer or History more Illuminating than in Boston, the City of Patriotism, Literature, Art and Science. Rich in Historic Interest, Because Here Were Enacted Many of Those Scenes Opening the Great Drama of our Nation's History.

# OLSEN TESTING MACHINES

***All the latest up-to-date testing machines***



**Olsen Latest Improved Ductility Testing Machine No. 2—*Patented*—with Pressure Weighing System for *sheet metal and wire testing.***

The very latest up-to-date type of testing machine for determining the drawing quality of sheet metal. The cupping is noted on dial directly from contact with the metal, while pressure is indicated on gauge which also indicates exactly when rupture occurs.

The most easily and quickly operated machine developed for such tests.

***Bulletin on application***

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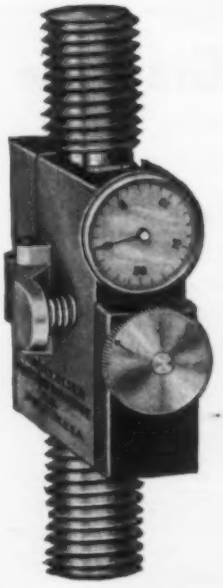


**Olsen Special Extensometer**
***Patent Applied for***

The most accurate and quickly applied Extensometer ever developed for use on the standard 0.505 inch diameter test specimen. Can also be obtained for use on wire or other size bar.

***Descriptive Bulletin on application***

---

**Manufacturers of Olsen Universal, Torsion, Brinell Hardness, Impact and Alternate Stress Testing Machines.**

---

**Olsen-Carwen Static-Dynamic Balancing Machines**

# Tinius Olsen Testing Machine Company

**500 N. 12th Street**

**PHILADELPHIA, PA.**

# POTS AND BOXES
OF "PYRO AND "CYRO" STEEL
GIVE
# UNUSUAL SERVICE

Our CYANIDE and LEAD POTS are made of a high grade Crucible Steel and give far better service than the ordinary steel pot. These "Cyro" steel pots will give you more furnace hours and cut your heat treat costs.

---

CARBONIZING BOXES made of our "PYRO" steel are giving satisfactory service in hundreds of plants throughout the country. Sound castings of uniform composition make them the best low priced container that can be secured.

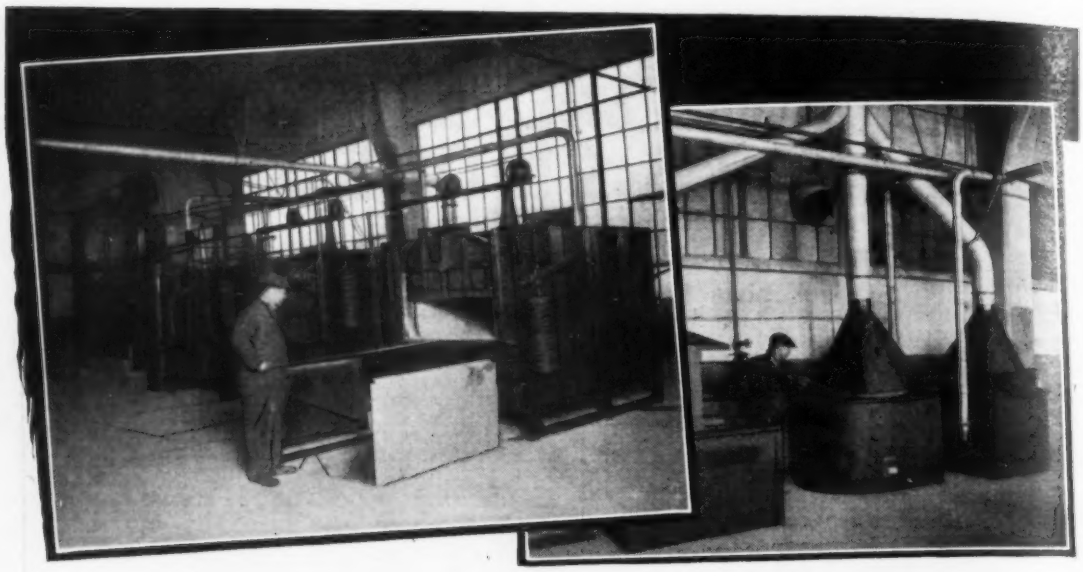
---

# Nickel Alloy

Our NICKEL ALLOY is made for those plants desiring a material that will not oxidize, warp, or crack when exposed to high temperatures. A high Nickel Chromium alloy made from the best of materials at the price of FIFTY CENTS per pound with FIFTEEN CENTS per pound scrap allowance.

*Patented May* 15, 1923.

## Swedish Crucible Steel Co.
**Detroit, Mich.**



Rickenbacker
A · CAR · WORTHY · OF · ITS · NAME

Again!—Rickenbacker Leads

*Announcing the*

"9th Fundamental"

*This is the New Fuel and Oil Rectifier* (licensed under Skinner patents) *which totally Eliminates Crank-Case Dilution* — greatest improvement in a motor since "Tandem Fly Wheels."

You have learned to expect from this progressive ... most advanced engineering discoveries ...

Another nationally known leader owns and operates RYAN Heat Treating and Furnace equipment. Industrial concerns and manufacturers who are accepted leaders have come to F. J. RYAN & COMPANY for their Heat Treating—Furnace—Oven and Automatic Temperature Control equipment.

Leaders go to leaders in other lines of endeavor—that is why RYAN engineers are being called in upon important work where only the best is wanted—or will be tolerated.

**Furnaces—Ovens—Heat Treating equipment using oil, gas, coal or electricity.**

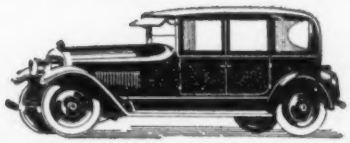
**Automatic Temperature Controlling for oil and gas.**

Ryan Heating Service
The Sun of Industry

INDUSTRIAL
F. J. RYAN & Co
HEATING SERVICE

WESLEY BUILDING PHILADELPHIA, PA.

Representatives in all Industrial Territories



# An Opinion From the Builders of One of the World's Finest Cars

THE manufacturer of one of the world's finest cars, whose policy, unfortunately, prevents the mention of their name in advertising other than their own, was recently asked whether they used Vanadium Steel and why.

The answer is interesting—and deeply significant to all who are trying to build a better car or make a higher grade part:

"Chrome Vanadium Steel is used in important forgings such as front axles, steering knuckles, steering knuckle levers, axle shafts, and in fact all forgings requiring high strength with good ductility.

"We have made many tests to show the improvements of Vanadium Steel over other steels of about the same cost.

"The fact that Chrome Vanadium Steel gives higher and more uniform physical properties than other types of alloy steel at about the same price is the quality which makes it a particularly good value."

There is little we can add, or would care to add, to this summing up of Vanadium advantages by a manufacturer whose reputation is world-wide.

May we, however, offer the assistance of our metallurgists in helping you to select a better steel for your particular purpose?

VANADIUM CORPORATION OF AMERICA

120 Broadway, New York Book Building, Detroit

# VANADIUM STEELS

*for Strength, Toughness and Durability*

# Red Cut Superior high speed steel

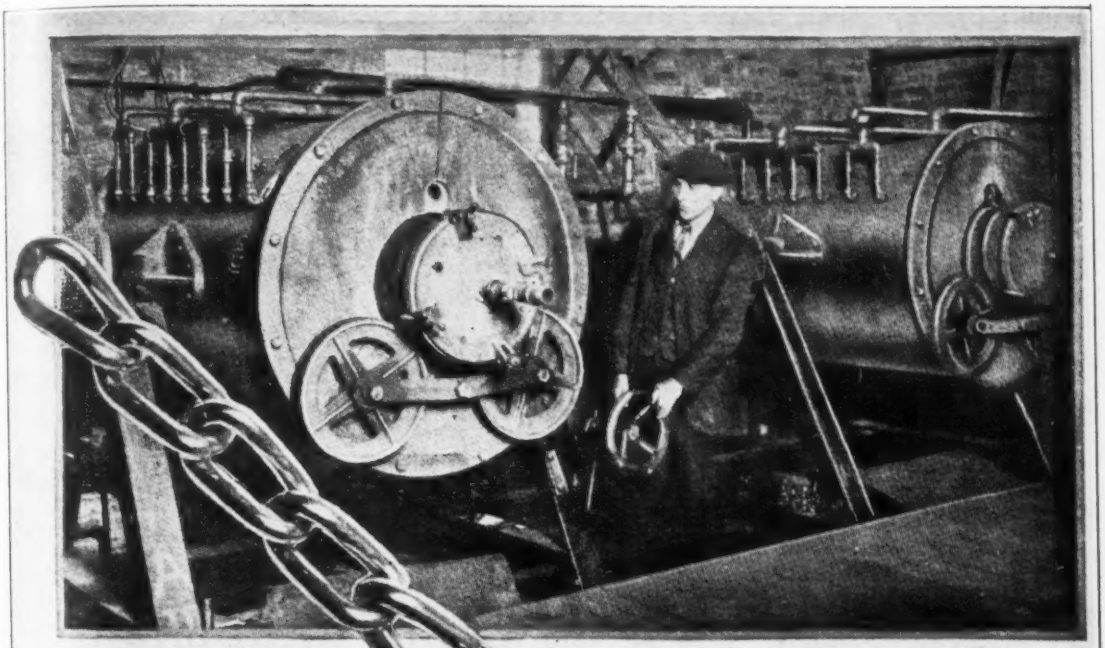
The Union Machine Company, San Francisco were experiencing difficulty in cutting a heavy tumbler shaft for use on a gold dredge. It is a chrome nickel steel tumbler and weighs some 40,000 pounds,—the overall dimensions of the shaft being 14 feet, 6 inches long, 23 inches diameter,—the tumbler diameter being 76 inches.

The operation on which several other steels had been used with very poor results was the taking of the first cut on the shaft as the material is very hard and full of sand. A "RED CUT SUPERIOR" 5/8-inch cutter was tried out to cut under the scale and the results were highly satisfactory, and very pleasing to the customer. It is needless to say that "RED CUT SUPERIOR" is used exclusively now for all their difficult cutting operations.

We would welcome an opportunity of proving its superiority to you in your shop—any time and on any operation you may select.

**VANADIUM ALLOYS STEEL COMPANY, Latrobe, Penna.**

Warehouses: Latrobe—Chicago—Detroit—Springfield—Los Angeles—San Francisco—St. Louis
Branch Offices:
New York—Philadelphia—Buffalo—Boston—Dallas—Cincinnati—Pittsburgh—Cleveland—Dayton



*"Take half the time and half the labor"*

**says WICKWIRE SPENCER**

If you wanted to compare the merits of various heat-treating methods, fuels, and equipment, you couldn't ask for better conditions than prevail in the Buffalo plant of the Wickwire Spencer Steel Corporation. This organization, famous for its steel products of all kinds, has had long and successful experience in the hardening, carbonizing and annealing of metal under varying conditions.

The two

## *AMERICAN Gas Carbonizing Machines*

above are entrusted especially with the heat-treating of chain of all sizes. In comparing its work with all other methods previously used, this firm advises that it not only consumes half the time and half the labor of the old methods but "produces a more uniform product—perfect heat control. More compact, with less maintenance cost."

**Whether your problem is the heat-treating and carbonizing of tiniest screws (6000 to the lb.) or large machine parts up to ½ ton, our equipment, backed by 44 years' experience, can save you money.**

*Let us estimate on your heat-treating problem—write today.*

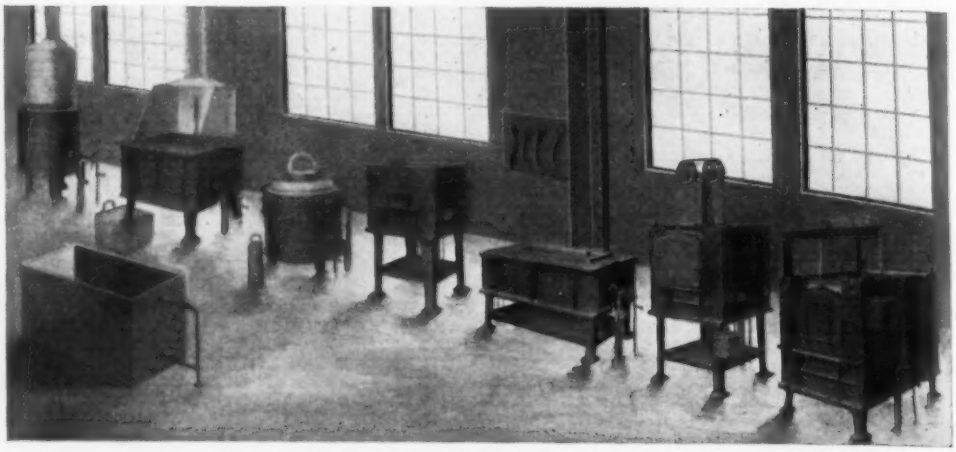
# AMERICAN GAS FURNACE CO.

**Main Office and Works: Elizabeth, N. J.**

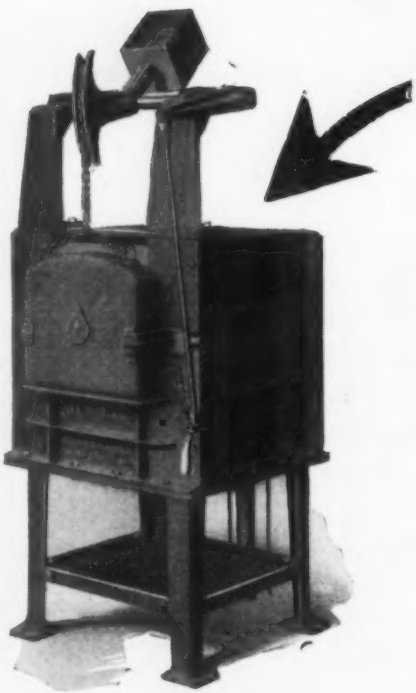
AMERICAN GAS FURNACE CO. PIONEERS IN 1878 LEADERS TODAY

American Gas Furnace Products Include:

- Automatic Heat Controllers
- Automatic Quenching Tanks
- Blowers
- Blowpipes or Blowtorches, Hand and Stand
- Boosters, Gas
- Brass Melters
- Brazing Furnaces and Tables
- Burners
- Burners for Electric Lamp Bulb Manufacture
- Carbonizing Machines
- Cyanide Furnaces
- Cylindrical Furnaces
- Forges
- Forges, Glass Bending
- Hardening Hammers
- Heating Machines
- Melting Furnaces
- Muffle Furnaces
- Oil Tempering Furnaces
- Oven Furnaces
- Plating Furnaces
- Rivet Heaters
- Soft Metal and Lead Hardening Furnaces
- Soldering Iron Heaters
- Sweep Reducing Furnaces
- Tempering Plates
- Tire Heaters
- Tube Heating Furnaces
- Every Type of Gas Blast Burner, Furnace and Heating Machine for Industrial uses.



A FEW OF OUR STANDARD SMALL FURNACES



GENERAL HARDENING FURNACES

SEMI-MUFFLE TYPE

FOR HARDENING AND ANNEALING HIGH SPEED AND CARBON STEELS

*Write for Bulletin 164-B*

We also specialize on large furnaces for oil —gas—or electricity

Tate-Jones & Co. inc.

Furnace Engineers Established 1898

PITTSBURGH, PA.

New York — Detroit — Buffalo — Philadelphia — Chicago — San Francisco — St. Louis

# FIRE ARMOR

***Progress is the Product of Collective Achievement***

**"FIRE ARMOR"** - - - - - The original and only high temperature material 2300°—2400° F.

**CASE HARDENING**
**ANNEALING BOXES**
**FURNACE PARTS**
**KILN FURNITURE**
**OIL CRACKING EQUIPMENT**
**GLASS MACHINERY PARTS, etc.**

—FIRE ARMOR stands up longer and better than other alloys because FIRE ARMOR is the only alloy designed and built to withstand maximum temperature conditions.

**Quality—Dependability**

## "FIRE-ARMOR"

## CHROBALTIC TOOL COMPANY

Railway Exchange
Chicago, Ill.

Mr. J. W. Mull, Jr.
717 Fletch Trust Bldg.
Indianapolis, Ind.

1701 Arch Street
Philadelphia, Pa.

Lorenzo Norvell Co.
Chemical Building
St. Louis, Mo.

Donovan Building
Detroit, Mich.

Mr. C. K. Kelly
344 Norwalk Avenue
Buffalo, N. Y.

# Show Your Colors

ALL MEMBERS of the A. S. S. T. should make a practice of wearing the Society emblem. It is neat and inconspicuous and immediately conveys the information that the wearer is a progressive individual and a member of a live, wide awake organization. The pin is in black and gold as shown above, with safety fastener, and will be mailed, post paid upon receipt of $1.00.

**AMERICAN SOCIETY FOR STEEL TREATING**

**4600 Prospect Ave.** **Cleveland, Ohio**



**No Initiation Fees**

## Application for Membership in the

# American Society for Steel Treating

**4600 Prospect, Cleveland, Ohio**

(See opposite page for Classification and rate for dues.)

*I hereby make application for (Member / Associate / Junior / Sustaining) membership in the Society, and agree, if elected, that I will be governed by the Constitution, By-Laws and Rules of the Society as long as I continue a member. I furthermore agree to promote the objects of the Society so far as it shall be in my power. $5.00 of my dues is for one year's subscription to the Transactions of the American Society for Steel Treating.*

*Date* .....

*Name* .....
(Please print)

*Firm Name* .....

*State fully what your firm manufactures or deals in* .....

.....

*City* .....*State* .....

*Are you in the Sales Department?* .....

*Title or Position with Said Firm* .....

*To what address do you wish your mail from this Society sent* .....

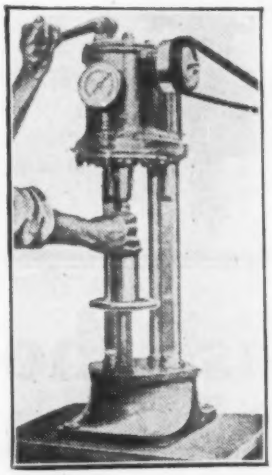
.....

*Endorsed by* ..... *Member*

**If candidate does not know any member of the Society, a reference will be satisfactory.**

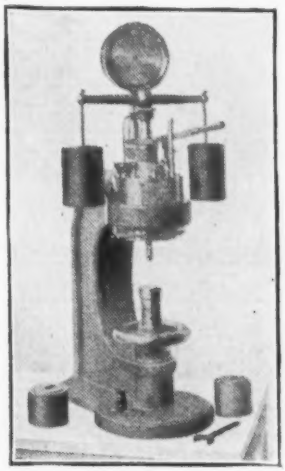
# BRINELL TESTING MACHINES PRE-EMINENT

***Used by the largest metal manufacturers, colleges and universities***



Type O
Power or Hand Operated.

Can be moved anywhere without dismantling any part.
Increases production. *Capable of making from 500 to 900 tests per hour.*
Lessens cost of Brinell Testing.
Dust proof.
Liquid tight without friction.



Standard Type of
Hand Operated.

Made in three sizes.

Style A-6½" Gap.
Style A1-12½" Gap.
Style A2-18" Gap.

Gap denotes the maximum dimension of flats, rounds or shapes that can be tested with each style machine.

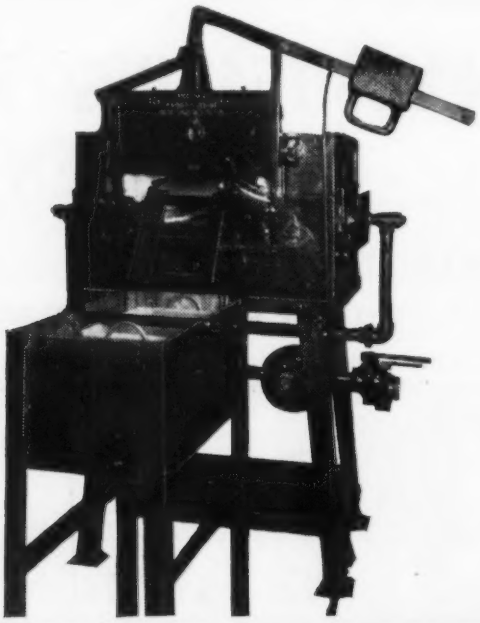
Vest pocket edition of Brinell Tables, Depth and Diameter furnished on request.

*Catalogs and Prices furnished on request.*

## Steel City Testing Laboratory

**Imperial Power Building**

**Pittsburgh, Pa.**



# Heat treating fish hooks

A MAN once said, after reading our advertisements, "Is there anything you folks *don't* do with heat!"

We told him that Surface Combustion furnaces are in use "wherever heat is used in industry"—10,000 successful installations testifying daily to the efficiency of One Valve Control and Automatic Proportioning.

The furnace illustrated hardens fish-hooks. It has a high rate of heat transfer—the work soaks through in a very short time. A hand lever dumps the finished work into the quenching tank, but holds the box on the rails.

Last month we illustrated a furnace recently installed in one of the largest automobile factories for heat treating cam shafts.

When will we illustrate an advertisement with a special furnace built for *you*?

THE SURFACE COMBUSTION CO.

*Industrial Furnace Engineers and Manufacturers*

General Offices and Works:

Gerard Avenue and 144th Sts.
New York

*Branches: In all of the principal cities of the world.*

# Surface Combustion

S-248 WHEREVER HEAT IS USED IN INDUSTRY

*When answering advertisements please mention "Transactions"*

## ROBERT W. HUNT CO.
*ENGINEERS*

PHOTOMICROGRAPHIC
CHEMICAL AND
PHYSICAL
LABORATORIES

INSPECTION
TESTS
CONSULTATION

LABORATORIES AT
PRINCIPAL OFFICES

RESIDENT INSPECTORS
AT STEEL MILLS AND
MANUFACTURING PLANTS

GENERAL OFFICE
CHICAGO

NEW YORK
ST. LOUIS
KANSAS CITY
PITTSBURGH
SAN FRANCISCO
CINCINNATI
LONDON
MONTREAL

## Columbia TOOL STEEL

FINE STEELS
MADE BY THE
CRUCIBLE PROCESS

CLARITE HIGH SPEED STEEL
OILDIE NON-SHRINKING
COLUMBIA SPECIAL CARBON TOOL STEEL
COLUMBIA EXTRA, ETC.

*It pays to use Good Tool Steel.*

COLUMBIA TOOL STEEL COMPANY
MAIN OFFICE AND WORKS
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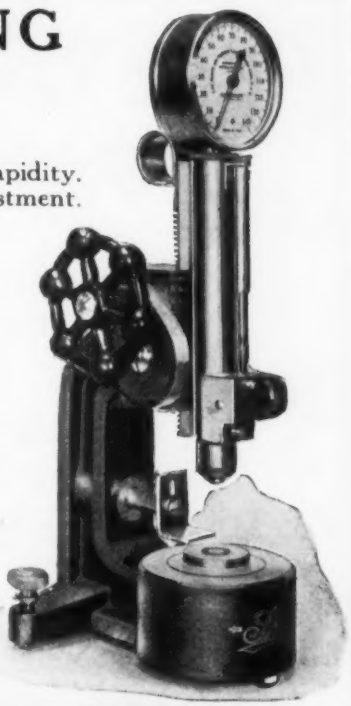

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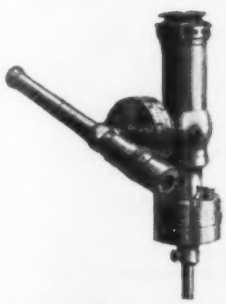

***Selective Carburizing Localized Hardening By SHORE Process***

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**Blaich Modern Carbonizers.**

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EXTRA REFINED
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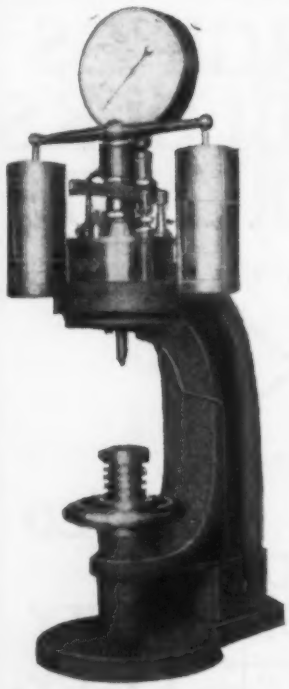

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We will make immediate shipment of these famous Swedish instruments, of which we have a good stock:—

**Alpha Original Brinell Machines**
For Hardness Testing.

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For Tensile Test Bars.

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A practical, accurate plant instrument for all high temperature work.

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1774

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1924

*Manufactured*

FOR 150 YEARS

## *FOR THE FINEST TOOLS*

*Imported from Sheffield*

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BEST CAST STEEL—Yellow Label

Recognized as the Standard Uniform Quality Tool Steel throughout the world.

***"The Value of Tool Steel should be measured by what it DOES, and not by what it costs."***

Composite Steel (combined Iron and Steel)
Double Shear Steel
Drill Steel—hollow and solid

Special purpose steels on demand

BILLETS AND FORGINGS
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STRIPS AND COILS

Hot and Cold Rolled.

*Made in America*

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Arrangements now completed for the production of Jessop's American Steels in Bar form at the enlarged works at Washington, Pa. The following available:

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Hot Rolled 20 gauge and heavier; widths 4″ to 18″; lengths to 70′.

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## Barkling No. 5 Oven Furnace

**U-Shaped Hearth Slab for Hardening High Speed and Carbon Steel**

***A Tool Room Leader***

**Dimensions**

**Opening.....5 in. x 9 in. Thickness of Lining...4 in.**
**Depth of Chamber.....14 in.**
**Thickness of Insulating 1½ in.**
**Floor Space.....30 in. x 30 in.**
**Shipping Weight....1,000 lbs. Height of Entrance...38 in.**

The **Barkling No. 5 Oven Furnace** is especially adapted to the hardening of small tools, dies, punches, blades, cutters, springs, etc. The U-shaped hearth slab permits the treatment of a considerable amount of steel at one time. Our method of combustion permits the heat to thoroughly penetrate the material without allowing the flame to strike direct.

We call particular attention to the insulation feature of the **Barkling Furnace.** This insulation practically prevents the heat penetrating to the outer shell of the furnace and results in a considerable saving of fuel.

The body is strongly built of heavy cast iron plates with sheet steel arch and is securely bolted on strong cast iron legs.

The door is of the counter balance type and is easily manipulated.

*Write us for catalog and price list. This will be of interest to you.*

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We always welcome a comparative test between "STECO" CASE HARDENING COMPOUND and any other make. You can find out more about "STECO" by actual use than we could tell you in ten times this space.

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**Speed isn't always synonymous with efficiency**

The Indian's smoke signal made with this blanket and a fire kindled slowly with flint chips frequently served him better than the more speedy runners.

Ever since the perfection of Ludlum Purple cut, high speed steels have proven far inferior to it for threading tools, tape, reamers, drills, punches, dies, etc. Reamers made of it have never been known to break in service; it is a super steel for tools requiring lasting, keen cutting edges; it is the only steel that does not suffer from carbide segregation.

***Let us tell you more about Purple Cut and our other special steels for special purposes.***

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Compact
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No other control device has so many desirable features.

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Bulletin 258-C shows many interesting applications of Rockwell Air-Tight Blast Gates. Write for copy.

**For Control of**

Air for furnaces, ovens, boilers, cupolas, dryers, kilns, etc.
Blowing scale from dies
Powdered Coal
Soot, Dust, etc.

The logical control device for you to use in similar work.

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Fahrite Castings represent the most complete range ever produced of heat-resisting alloys of varied analysis. They are giving service up to 2200°F. Quantity production, together with improved processes has enabled us to set a new level for low prices.

An important factor is the manufacturing organization in back of this production. The 15 years' reputation of the Ohio Steel Foundry Company — with its three completely equipped plants and technical laboratories, and its 4,000 tons monthly production, give ample surety for the necessary manufacturing skill, highly specialized technical knowledge and responsibility of claims.

We provide you with the right alloy for the right purpose—at the right price.

If you have been paying the usual nickel chrome and ferrochrome prices, it will pay you to investigate Fahrite Castings.

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**Springfield, Ohio**

**Works: Lima Springfield Bucyrus**

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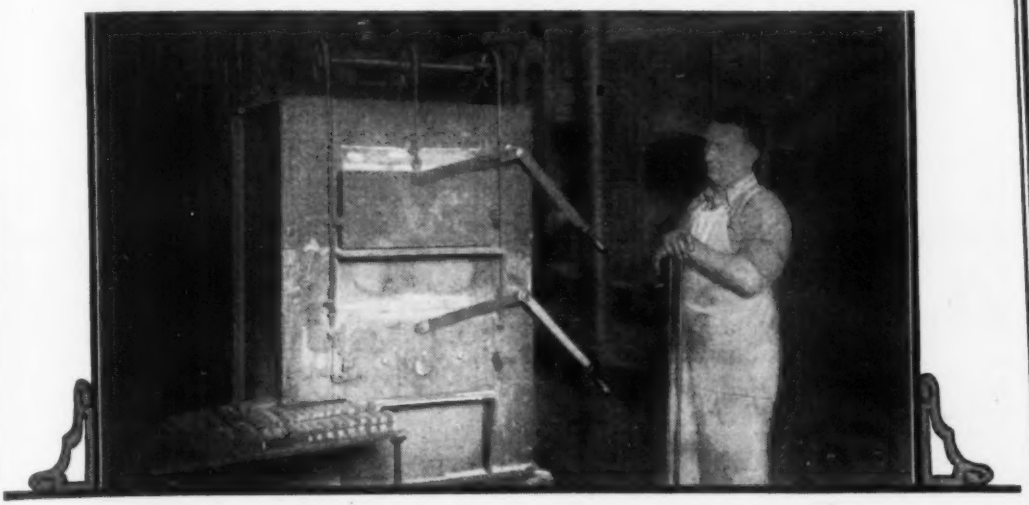
***FAHRITE CASTINGS***

***are serving in these and many other applications:***

**Carbonizing Boxes, Lead Pots, Annealing Boxes and Equipment, Furnace Hearths, Grates and Stoker Parts, Rolls, Chains, Links, Bars, Rails, etc., for continuous Furnaces. Enamel Burning Equipment, Stirring Arms and Parts for Metallurgical Roasting Furnaces, Retorts and Tubes for Oil and other Chemical Processes, Parts for Glass-making Machinery, etc.**



# Carbofrax Brings the Heat to Your Ware Eight Times as Fast as Fireclay

THERE is no other commercial refractory material that has the remarkable heat conductivity of Carbofrax—the Carborundum Refractory.

With Carbofrax hearths in your heat-treating furnaces you are assured of a uniform flow of heat which is reflected in the more uniformly heated ware—in the saving of fuel and increased general efficiency of the furnace.

With a Carbofrax hearth you can bring the furnace up to heat much quicker and you can hold it there.

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They show a decided resistance to abrasion and they will last months as against weeks for fireclay.

Made for all standard furnaces in one piece up to 24 x 15 and 24 x 24 inches—larger hearths in sections.

***Write our Sales Engineering Department regarding any problem dealing with Refractories***

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Refractory Division

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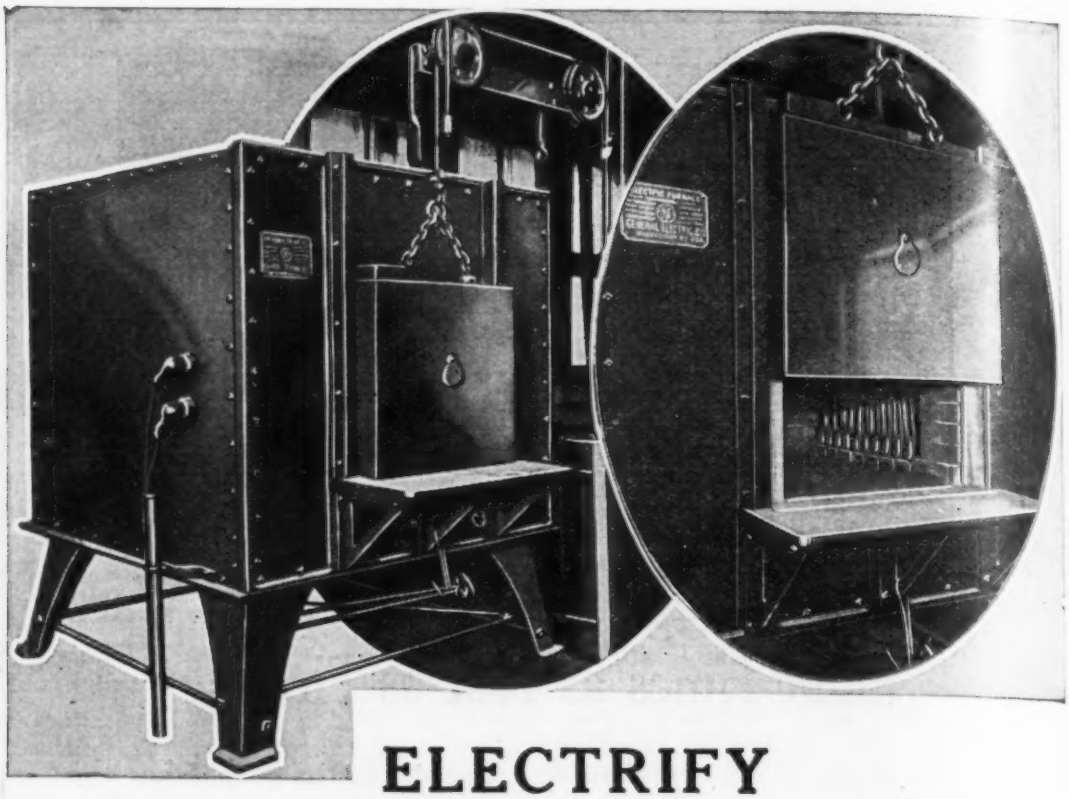
**Williams & Wilson, Ltd., Montreal**



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## *Your Heat Treating Process*

A manufacturer of Metal Stampings uses this Electric Furnace, equipped with G-E Direct-Heat Units and Automatic Temperature Control, for hardening dies and tools. It was installed about two years ago and has given very satisfactory service always.

"It's the best tool in the Hardening Room!" says the heat-treating-shop foreman. "I get a half day's work done by early morning." His enthusiasm results from the ease and speed with which this furnace operates, and the accuracy of temperature control.

G-E Direct-Heat Electric Furnaces, complete in standard sizes, and G-E Direct-Heat Units to equip larger size electric furnaces—are manufactured by the General Electric Company, Schenectady, N. Y.

**General Electric Company**
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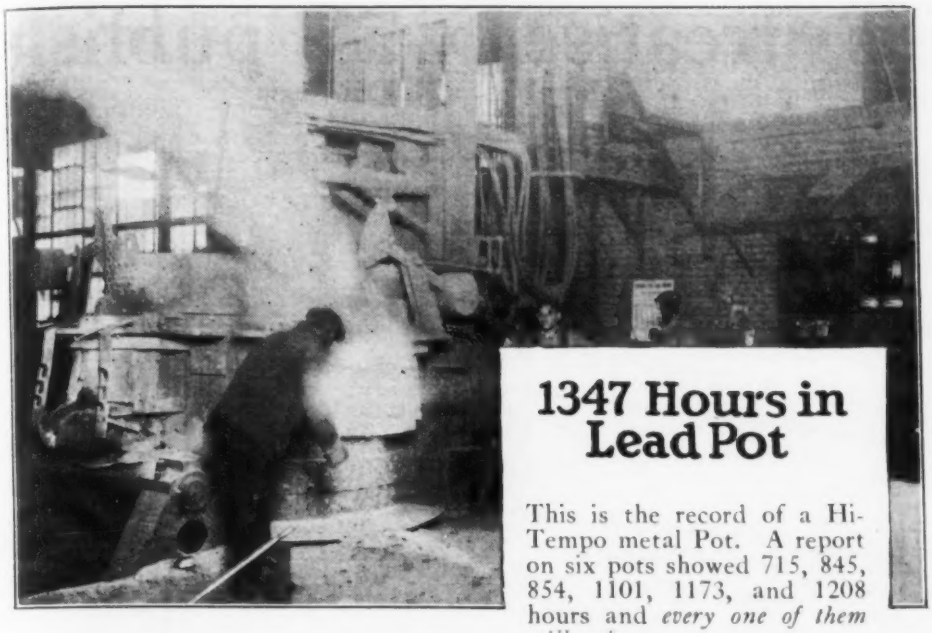
**Sales Offices in all Large Cities**

# GENERAL ELECTRIC

39-110C



## 1347 Hours in Lead Pot

This is the record of a Hi-Tempo metal Pot. A report on six pots showed 715, 845, 854, 1101, 1173, and 1208 hours and *every one of them still going.*

Another pot finally burned out after running 1347 hours.

This is the kind of service Hi-Tempo pots are giving in plants all over the country—averaging above 1,000 hours. And Hi-Tempo costs but a fraction more than ordinary steel.

Hi-Tempo is made by a patented process. It has extraordinary heat-resisting qualities as the foregoing shows. And as a result it is being used for dozens of things besides pots and boxes—annealing boxes, hearth plates, grate bars, galvanizing boxes, etc. In other words wherever there is heat.

We have numerous patterns in stock. Write us your size and requirements—we will quote you surprising money saving prices.

### New Uses Developing Every Day

This is the third of a series of advertisements, we have published telling of the heat resisting qualities of Hi-Tempo Metal. In the mail the other morning were three inquiries—all asking about Hi-Tempo Metal for uses entirely different from pots and boxes.

Undoubtedly you can think right away of places in your plant where iron or steel is being used in close contact with heat and is warping and cracking all too soon. Hi-Tempo Metal will not warp, crack or burn through like ordinary metals. It will save you time, trouble and money. Send details for prices.

*Use*

**Case Hardening Service Company**
**2281 Scranton Road, Cleveland, Ohio**

**Bell & Gossett Company**
**117 North Dearborn Street, Chicago, Ill.**

# Hi-Tempo Metal

## Wherever There Is Heat

# This treatise was published for YOU

The Cooling of Quenching Oil in the Heat Treatment of Steel

BY KENNETH B. MILLETT

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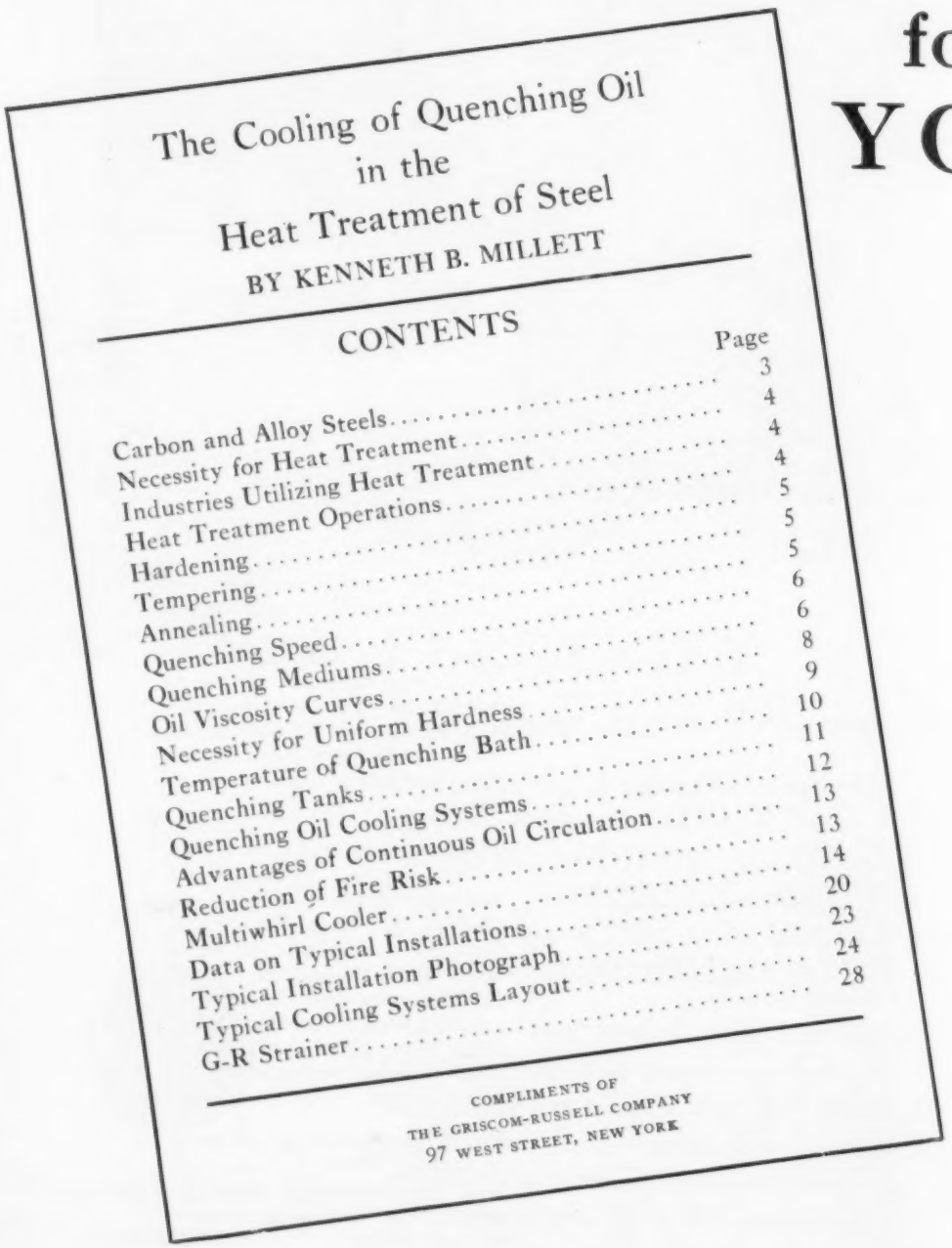

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COMPLIMENTS OF
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The information contained in this booklet is authoritative, and is valuable to every steel treater. It discusses proper heat-treating temperatures and operations, explains the most approved practice in steel treating, and describes quenching and cooling equipment that has given the most satisfactory results in hundreds of progressive plants such as Buick Motor Co., Falk Co., Hyatt Bearings Division of General Motors Corp., Packard Motor Co., and Ingersoll-Rand Co.

If your industry touches the heat treatment of steel, do not fail to write to the Griscom-Russell Company, 97 West Street, New York City, for a free copy of the treatise.

# Cut Your Heat Treating Costs!

One shop using Lavite and figuring carefully reported a saving of over 30 percent.

They found that with Lavite for $49,663.92 they had done work which by their former oven furnace and lead heat treating process would have cost $74,612.73 or about one-third *more*.

Of course, pots and Lavite cost money, but the saving is surprisingly big in furnace time, labor charges and supervision, the really important items.

Consult us about your problems.

You should make large savings with

LAVITE

**The Bellis Heat Treating Co.**

**102 Blake St.** **New Haven, Conn.**

BELLIS LAVITE

***The new medium that makes Heat Treating an Exact Science***

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PISTON RODS
DIE BLOCKS
TRIMMER STEEL

# The Economy and Wisdom of Better Steel

THE steel that goes into your product is a poor place to practice any but the best kind of economy—the economy of more uniform, dependable steel. Forging and machine work are too costly and reputation too valuable to entrust them to steel of doubtful character.

To those who place quality above other considerations, Tacony offers a complete range of high grade carbon and alloy steels. With these steels—or in advance of them—goes a helpful metallurgical service backed by extensive research facilities.

May we help with your steel problem?

ALLOY AND CARBON STEELS
*to*
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HOT ROLLED AND COLD DRAWN BARS
STANDARD AND SPECIAL SHAPES
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**OUTFIT**
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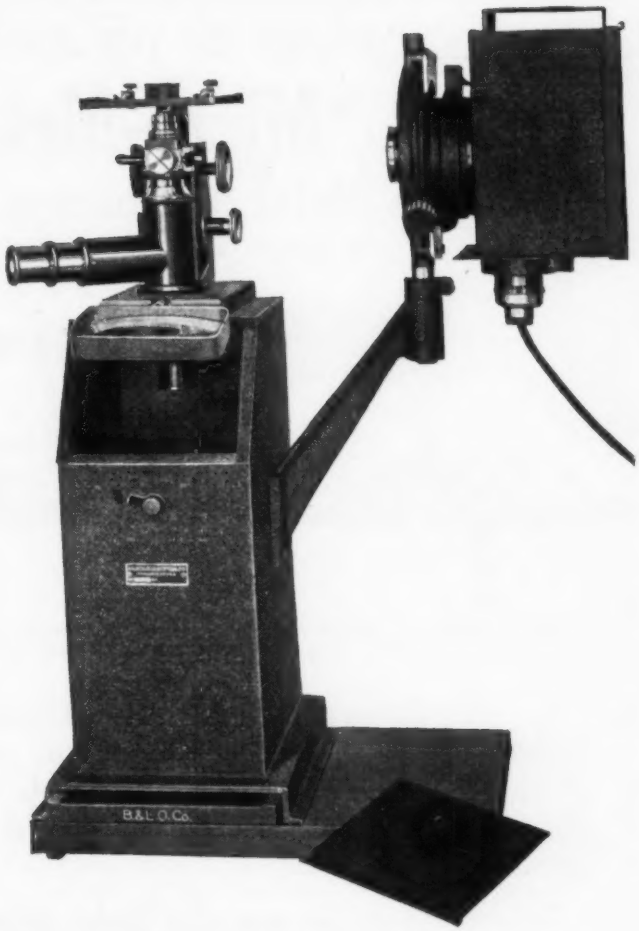


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seldom requires magnifications exceeding 200 diameters. Realizing this, and also the fact that smaller plants cannot always afford the more expensive outfits which are capable of research work, we have developed this new equipment.

This simplified outfit is equipped with an inverted microscope, a camera and a 6-volt, 108-watt ribbon filament illuminant in one compact unit. It is very simple to operate, easily portable and especially suited for low power work. The image can be observed through an opening in the top of the dark chamber upon a white screen at the bottom. A focusing glass, which is not a part of the regular equipment, is mounted over the opening of the dark chamber for accurate focusing of the image.

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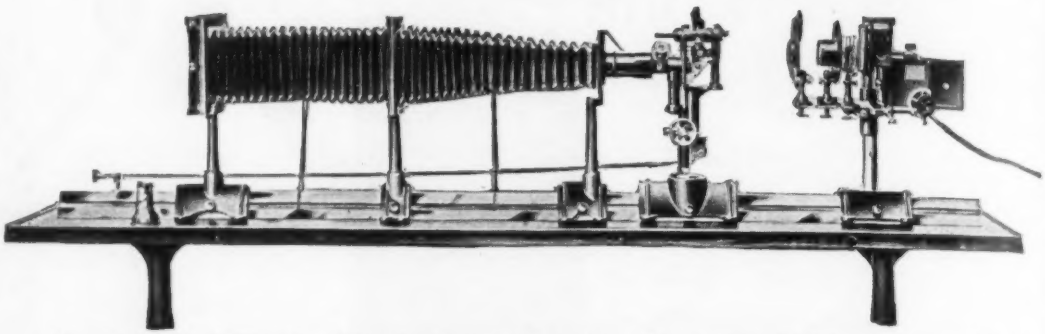
# Leitz "Micro-Metallograph"

## —Large Metal Microscope with Camera—

**In Stock For Immediate Delivery**



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Micro-Analysis are the only dependable methods towards improving manufacturing conditions in mills and foundries; without them tests are mere guesswork, production is unreliable and costly.

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# Distinguished Service in Two Different Fields—

In the field of electric heating Nichrome dependability has been established by nearly 20 years of performance. Nichrome wire, ribbon and strip convert electric energy into heat.

To be sure of getting the distinguished service of which Nichrome is capable, write this specification into your orders for electric furnaces, ovens, etc. * * * ***"Heating units of Nichrome—the Driver-Harris Resistor"***.

* * *

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